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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY,

ESTABLISHED NOVEMBER 13, 1807.

VOLUME THE FIFTH.

Quod si cui mortalium cordi et curæ sit, non tantum inventis hærere, atque iis uti, sed ad ulteriora penetrare; atque non disputando adversarium, sed opere naturam vincere; denique non belle et probabiliter opinari, sed certo et ostensive scire; tales, tanquam veri scientiarum filii, nobis (si videbitur) se adjungant.

Novum Organum, Præfatio.

London:
PRINTED AND SOLD BY WILLIAM PHILLIPS, GEORGE-YARD, LOMBARD-STREET.
1821.

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Geological Society,
Sept. 1, 1821.

It is requested that all letters and communications to the Secretaries, and presents to the Society, be addressed to the House of the Geological Society, No. 20, Bedford Street, Covent Garden, London.

ERRATA.

Page 344	*for*	Berezowsky	*read*	Berezovsky
ib.	——	Lagoda	——	Ladoga
ib.	——	Walaam	——	Valaam
ib.	——	Platten Sea	——	Platten See
345	——	Kevgnemy	——	Kevynemy
395	——	Bechka	——	Rechka
ib.	——	Newsky	——	Nevsky
ib.	——	Cester Back	——	Cester Bach
398	——	bog	——	bay
ib.	——	Biabova	——	Riabova
ib.	——	Capsala	——	Copsala
ib.	——	Biabova	——	Riabova
ib.	——	Corpsala	——	Copsala
399	——	Palcova	——	Pulcova
ib.	——	Jossna	——	Tosna
411	——	Pavloosk	——	Pavlovsk
412	——	Pavloosk	——	Pavlovsk
422	——	Skoovitza	——	Skvovitza

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GEOLOGICAL SOCIETY,

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VOLUME THE FIFTH.

PART THE FIRST.

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1819.

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I. *On the Island of Salsette.*

By STEPHEN BABINGTON, Esq.

OF THE HONORABLE EAST INDIA COMPANY'S CIVIL SERVICE, BOMBAY.

Communicated by WILLIAM BABINGTON, M.D.

[Read 19th January, 1816.]

THE columns of Dharaire are situated on the eastern face of a range of hills, which at a distance appears to form part of the Island of Salsette, but which is in reality insulated by a creek which branches from the river that divides the northern extremity of Salsette from the Mahratta coast, and which, passing along the foot of the hills, meets the sea again towards the south-west, its whole length being not probably more than four or five miles.

The general appearance of the range of hills, when seen from the eastward, justifies the conjecture that columns might be traced wherever the surface of the rock has become exposed; but the clusters of pillars which are the most remarkable, are within two hundred yards of the northern extremity.

Nearly the whole of the rock in this particular spot is laid bare, and the columnar form is to be observed even at the base of the hill. The loftiest columns however spring from the earth at about one-third of the height of the hill. There are three distinct clusters; those in the center and to the left are nearly of equal size, but the mass on the right is considerably less lofty.

The general appearance of each cluster, viewing it from the base, is that of a bundle of reeds, the pipes of an organ, or a section of a honey-comb; the height of the most lofty columns is about fifty feet, and although in some instances horizontal fractures are discovered, they appear to be the effect of accident, as the greater number of pillars are single shafts.

On ascending the hill it is perceived that there are other clusters of columns rising in succession behind the principal one, each being elevated about eight or ten feet above the cluster immediately below it.

The diameter of each column in the three clusters above described, is about twenty inches, but there are columns in the neighbourhood of more than double that size.

The number of the sides of each column varies from four to seven, and in one instance the four exposed sides of a column, led to a conclusion that the whole figure was an octagon. The figures which occur most frequently are irregular pentagons and hexagons. When the figure has only four sides, the sides are nearly of an equal size; the same observation applies also, though not so universally, to the pentagons, but the hexagons and seven sided figures have frequently one or more sides not exceeding two inches in diameter.

Almost all the columns face the east, perhaps a little northerly, and incline to the south-west. The angle of inclination is extremely variable, but the three main clusters lie nearly in the same parallel, and incline about twenty degrees from the perpendicular. The inclination of many of the surrounding columns is as great as sixty or seventy degrees.

The rock of which these columns are composed, is internally of a light bluish grey colour, its exposed surface is of a dark reddish brown colour, resembling the rust of iron, and the stone to the depth of about three quarters of an inch has undergone partial decomposition, and assumes a dirty red colour. The stone is sufficiently hard to strike fire with steel, but it is easily scratched by a file: its fracture is irregular and its grain not very close.

I am informed the rocks along the whole of the western shore of Salsette, particularly near a place called Versooa, have the columnar form. The western hills of Bombay bear traces of the same formation also, but the Bombay rock is much darker in colour, closer in grain, and of greater specific gravity and hardness, than that of which the Dharaire pillars are composed; and the different shafts of which the clusters are made up, are cemented together by thin strata of a lighter coloured substance, instead of, as at Dharaire, merely fitting closely to each other.

II. *Remarks upon the Hills of Badacson, Szigliget, &c. in Hungary.*

BY RICHARD BRIGHT, M.D.

MEMBER OF THE GEOLOGICAL SOCIETY.

[Read 17th May, 1816.]

THE small town of Keszthely in Hungary, is situated on the north and west shore of the Balaton Lake, or Platten See. The country around is generally flat and alluvial, but a low ridge of limestone hills covered with forest, stretches towards the north and west, leaving a strip of marshy land between it and the lake. The road runs along the raised bases of these hills, and conducts towards Tapolcza, leaving the lake several miles to the south. The country now exhibits one extensive and marshy plain, in the midst of which are seen a few small detached mountains whose sides are clothed with vineyards and their summits broken with rocks. Of these I visited the four most striking, namely, Csobantz, Badacson, Szigliget, St. Gyorgay-hegye; and it is from two of these that the specimens which accompany these observations were obtained.

In ascending Csobantz, we first came to a pit dug in the side of a hill, which presented nothing but a horizontally stratified yellow sand, generally crumbling down under slight pressure, and full of glittering particles, I believe micaceous. A few paces farther we found extensive scoriated masses firmly fixed, and to all appearance in their natural situation, forming part of the solid rock. Proceeding a little higher, the rock was a species of greenstone, or perhaps lava, but suffering considerably from the action of the weather, and then thickly beset with little hollows, slightly indented and about the size of a pea; this was of a light grey colour, and in its structure quite amorphous. Still higher, the same rock became more hard, and shewed a tendency to assume a vertical columnar division.

Such was the formation of this hill, of which however I possess no specimens.

The lower part of the hill Badacson, was completely covered with vegetables, but on ascending about half way we found the whole strewed with fragments fallen from above, amongst which were masses of very vesicular scoriæ.

The path leads through columnar rocks, called the Iron Gateway, formed of a very compact, hard, dark coloured stone, of a crystallized texture, rather resembling clinkstone. In other parts, towards the summit, the rock is of a greyer colour, containing numerous small particles of olivine and a few vesicular cavities. It here assumes the general, though not regular columnar form, and splits again horizontally into layers of six or seven inches in thickness. The highest part of this insulated hill is covered with wood, and many of the oaks have attained a large size where their growth has been favoured by an irregular natural excavation, formed by the disposition of the surface. Descending on the west side of the hill where the rock was more denuded than at the part we had first approached, I was not a little surprised to meet with a sandstone conglomerate, bearing a very exact resemblance to the only rocky mass which occurs on the ascent of Hekla, and is found forming complete mountain ranges in Iceland, as will be found ably described by Sir George Mackenzie.

The third hill, named Szigliget, presented at its base, and below the village of that name, the same conglomerate, and to appearance the whole hill was composed of this substance. On ascending however towards a ruined castle which stands upon the summit, I observed this conglomerate assuming a more bold and rocky form, and on examination found that it was of a much harder texture, and the parts of which it was composed appeared more completely amalgamated together. After proceeding a few steps farther I found myself upon a regular vein, of about 12 or 14 feet in thickness, running almost perpendicular downwards as far as vegetation allowed the rock to be visible, and upwards to the summit.

This vein was of a very compact and heavy substance, of a dark colour, with sparkling crystallized particles; and was upon the whole a mineral which I did not hesitate to consider basaltic greenstone. Towards each side, for the width of two or three feet, it was broken into irregular angular flat pieces, and might be called shattery, but towards the centre it was more firm, and very decidedly split into irregular horizontal columns.

The junction of this vein with the surrounding rock is abrupt and well marked; yet they adhere closely together, and with some care may be procured united in the same specimen.

With respect to the mass of rock; it is composed of what appear to be innumerable fragments of basalt or lava with small white crystals disseminated through them. These fragments are united by a yellow-brown semicrystalline matrix, and in parts where least compact shewing distinct grains as of rubbed siliceous sand. Through this mass are distributed collections of vesicles giving the precise appearance of scoriæ, but not presenting a defined edge of separation, as if they had been included masses; but on the contrary so forming a part of the substance of the rock as to suggest an idea that the whole had been very nearly, if not quite in a state of fusion, at the time when it assumed this appearance; and this view of the subject is rather confirmed by the very intimate union which exists between all the parts of the conglomerate. It is however possible that the scoriated appearance does actually arise from scoriæ included in the mass, so that on the application of intense heat a partial fusion takes place, by which the matrix and the included substances have been closely united together.

Upon the summit of the hill and forming the foundation of the castle, the conglomerate, still containing the same substances, is found in a form somewhat different, disposed in beds of various thickness with a very distinct separation between them, both surfaces of the beds being composed of projecting and slightly adhering angular particles of which the greater part is composed. These beds are perhaps at an angle of about 45° to the horizon. They are several yards distant from the vein, part of the general conglomerate filling up the intervening space.

The important conclusion to which these facts incline my mind is, that a vein which resembles in its characters a true basaltic greenstone, has owed its origin to the action of fire.

No one can look upon the hills of which I have been speaking, and observe how insulated they are from all mountain chains, mark their form, their abrupt sides and their flattened tops, without being convinced that they are but remnants left by some convulsion, tearing away parts which either connected them together, or made of each a more perfect whole. We must therefore put their form entirely out of consideration, and look upon them simply in the light of fragments, retaining their natural situation.

As such then we find in the first a hard columnar mass, in close connexion with a great mass of scoriated lava, over which it lies.

In the second, we find the upper part composed of a mass of stone with vesicles in it, and which on comparison will be found to differ very little from the Icelandic lavas of Havnefiord. The under part of the mountain consists of a tuffa, or conglomerate, probably volcanic.

In the third, the very same tuffa is found at the bottom; there is however no hard or columnar mass above it. The elevation is considerably less than that of the other two; which may perhaps be accounted for by this deficiency, but we find extending to the summit a black columnar vein passing through the conglomerate, to which it adheres firmly on both sides. The conglomerate is here more compact than elsewhere, and contains within it appearances of scoriæ.

Taking then these facts in connexion, does it not seem that the conglomerate which forms the lower part of the second hill, and the greater part of the third, was in its situation before either the vein in the one, or the cap in the other, were deposited. That this was probably the result of some ancient volcano, or of eruptions of sand and scoriæ which proceeded from a volcano that afterwards poured forth its stream, forming a thick covering over the surface of the deep sandy plain, and sinking into those fissures or crevices which existed in its course.

III. *Some Observations on a series of Specimens presented to the Geological Society, by the Hon.* H. G. BENNET.

By ARTHUR AIKIN, Esq.

MEMBER OF THE GEOLOGICAL SOCIETY.

[Read 21st February, 1817.]

ON the 15th of June, 1794, a stream of lava flowed from Mount Vesuvius into the sea. The town of Torre del Greco, situated on the shore of the bay of Naples, was in part overwhelmed and buried under the fiery torrent. On the 16th of June, 1795, according to the testimony of M. Breislak, in his "Topografia Fisica della Campania," the lava had so far cooled, that a thermometer placed in the crevices rose only to 178° Fahr. and new buildings were already begun to be erected on the warm lava. In digging foundations for these houses, the ruins of those which had been overwhelmed by the lava, were occasionally broken into, and several articles were thus recovered which had been exposed to a heat of greater or less intensity, for the space of a year. The most complete and curious collection of these was made by the late Dr. Thompson. Many interesting specimens, however, were acquired by the Hon. H. G. Bennet, and with his accustomed liberality, have been presented by him to the Geological Society. By his desire I have examined these specimens, and the following notice is offered to the candour of the Members, instead of the dry detail of a mere catalogue.

The earthy matter adherent to some of the specimens, and which I consider as having formed part of the lava, No. 11, is deeply coloured by oxide of iron, has a completely earthy appearance, and is in general but little coherent. The only distinct minerals which I have observed to be contained in it are, scales of yellowish and silvery white mica, usually very minute, and pieces (which appear to be fragments) of finely granular carbonate of lime, effervescing strongly with acids.

The specimens of glass in this collection are particularly interesting, as shewing a variety of changes which this substance is capable of undergoing, by the continued action of a moderate degree of heat.

No. 1 is a fragment of a looking-glass, seeming at first sight to have undergone no alteration, except that the metallic lustre of the silvering is gone, and the upper surface of the glass appears as if it were dirty: this dirt, however, is not to be removed by washing with water, and on inspection with a lens appears to be the commencement of a decomposition or change of structure, for in the dull parts are seen many small circular portions that still retain their lustre, and some little cavities appear where the substance of the glass has been more rapidly acted on than elsewhere.

No. 2 are specimens of glass exhibiting the next change of structure: some of these are merely become dull and almost opake superficially, the interior being unaltered; in others may be seen the commencement of a fibrous structure, penetrating from each surface to the depth of about one-eighth of an inch into the interior of the mass.

Nos. 3 and 4 are masses composed of flat pieces of glass, which having been softened by exposure to a heat almost equal to their fusion, have sunk down upon each other, without, however, becoming actually united or incorporated, although some of the pieces are more or less vesicular. Externally they are partly of an opake white and partly of a dingy purple; the interior surface of the vesicles being also of this latter colour; the recent fracture exhibits a very pale sea green colour, passing into yellowish, and transparent, but with little or no lustre; the structure is confusedly, and divergingly radiated, resembling considerably the commoner varieties of Prehnite. The external surface, in many parts, presents stellated groups of minute shining white crystals. Its hardness is such that it scratches glass with great ease; it yields, however, to the file.

No. 5 shows the ultimate degree of change, the structure having become cellular, and the fracture compact.

Nos. 6 and 7 are specimens of glass which have actually undergone fusion, and are converted into more or less cellular masses, enveloping pieces of lava and other matters. The structure and general appearance of these differ much less from that of ordinary glass than the specimens above described.

No. 10 is a parcel of small glass beads, the form of which is but little altered, although they have been agglutinated together, and the structure has become cellular.

No. 8 is a cellular slag of a dirty brown and yellowish colour, the origin of which is not very apparent: perhaps it has been produced by an intimate mixture of glass and of lava.

No. 9 is a fragment of common pottery. The blue vitreous glazing has become more or less cellular, but the pottery itself has undergone no change. It may also be mentioned that in No. 6, already described, a piece of porcelain is inveloped in the glass; this fragment does not appear to have been in the least degree softened, but its fracture displays a more granular structure than ordinary, and a glimmering lustre.

From the above described specimens, we may conclude that glass when exposed to a long continued natural heat, undergoes changes of structure very analogous to those which have been produced on this substance in our laboratories, by burying it in red hot sand, except that (as might be expected) the slower process has produced the more crystalline structure. The slight change of structure produced in those specimens, which have actually undergone fusion, also coincides in a remarkable manner with the experiments of Reaumur, who first directed the public attention to this interesting subject, which has since been applied, very ingeniously and plausibly at least, to the solution of a very important class of geological phenomena.

The changes produced on bars and utensils of iron, are not less remarkable than those which have already been described, and since they have not been anticipated by analogous experiments, made purposely in the laboratory, I shall take the liberty of mentioning them somewhat in detail.

No. 12 is a mass of iron, probably a piece of a cylindrical bar. The external part of the specimen, although rifted longitudinally, exhibits a considerably compact structure, and appears to be a mixture of the black and red oxides of iron; it dissolves without effervescence in muriatic acid, and acts on the magnetic needle, but not very powerfully. The interior is a mass of grey oxide in confusedly octohedral crystals, acting very strongly on the magnetic needle, but not possessed of polarity.

Nos. 13 and 14 differ but very little from No. 12, except that some of the cells are lined with a white vitreous substance, from which acicular crystals of the same have shot from one side of the cell to the other.

No. 16 is part of a tube which has been reduced to the state of magnetic oxide; the cavity is lined with minute brownish red transparent crystals of oxide of iron.

No. 19 is a mass, apparently broken from No. 13, in the interstices of which are well defined crystals of specular iron ore.

No. 20 is a mass of iron reduced to the state of crystalline black oxide, and differs from all the other specimens, in being possessed of magnetic polarity, both in mass and in fragments.

No. 15 is a mass, probably part of a bar, with lava adherent to it: the whole is in the state of magnetic oxide, except a central cylindrical piece a few inches long, and about one-fourth of an inch thick. This piece, on being bent backwards and forwards once or twice, breaks, and exhibits a completely crystalline structure, with a tin white colour and lustre. It has no polarity, but acts powerfully on the magnetic needle, and is soluble in muriatic acid, with a copious disengagement of hydrogen gas. It is therefore iron in the metallic state, having acquired, by the long continued action of heat, a crystalline arrangement, and is probably entirely free from carbon.

No. 17 is an agglutinated mass of nails. The thicker ones appear to have been of cast iron, and are converted into a dark grey oxide, the thinner ones appear to have been of bar iron, and are still malleable, but in colour and structure resemble the specimen just described.

No. 18 is a key, the central part of which is in the metallic state, while the exterior is in the state of red, and of magnetic oxide.

From this series we may conclude—First. That the proportion of free sulphur in the lava, if any, must be very minute, since there is not the least appearance of any iron pyrites.—Secondly. That iron, by exposure for a sufficient length of time to a temperature by no means sufficient to melt it, or even materially to alter its form, may be converted either into massive oxide, with a perfectly crystalline structure, and sometimes possessed of magnetic polarity, or into crystallized oxide, the latter being manifestly, in many cases at least, produced by sublimation, thus shewing the volatility either of iron or of its oxide, at a much lower temperature than has ever before, I believe, been observed.

The other metals contained in this collection, namely, copper and lead, offer but few circumstances worthy of remark.

No. 19* is a heap of copper coins, the legends on some of which are still very visible. These pieces are cemented together by crystalline red oxide of copper, so that a section of the mass would present an alternation of thin laminæ of metallic copper and of red oxide. The metallic portion appears to be softer than ordinary copper, and presents no traces of crystalline structure.

Nos. 20* 21, 22, are specimens of copper now converted into red oxide, mixed with green and blue carbonate.

Nos. 23 and 24 are specimens of copper converted into semi-transparent red oxide, with more or less of an external crystalline form.

No. 25 is a small bell, the figure of which is but little altered; it is, however, entirely converted into alternate layers of red oxide of copper, and of white oxide, probably of tin.

No. 26 is a mass of common pins, retaining much of their original figure, but rifted longitudinally. The structure of each pin has become concentric, like a stalactite, and the surface is covered with extremely minute crystals, which I consider as red oxide of copper.

No. 27 is metallic lead, the surface being more or less oxidated. Mixed with the lead, and partly separated from it, are little crystalline masses, with rectangular joints, that have all the external characters of galena. This galena, I am inclined to consider, not as produced by the union of sulphur from the lava with lead, but rather as the effect of a depuration of the lead in consequence of long exposure to heat. The uncommon softness of the metallic lead in these specimens, is a circumstance certainly favourable to this theory.

Nos. 28, 29, 30, are specimens of compact minium, with a glimmering lustre, and a semi-crystalline structure. The latter of these has evidently been a mass of common shot.

IV. *Remarks on the Chalk Cliffs in the neighbourhood of Dover, and on the Blue Marle covering the Green Sand, near Folkstone.*

By WILLIAM PHILLIPS, Esq. F.L.S.

MEMBER OF THE GEOLOGICAL SOCIETY.

[Read 2d January, 1818.]

THE natural section of the chalk, presented by the cliffs extending from Dover about eight miles eastward towards Deal, and five miles westward towards Folkstone, affords the opportunity for observing the nature of that formation, and the numerous falls on the shore, occasioned by accident or design, give more immediate access to the study of the organic remains they inclose.

The highest point of the range is in the immediate neighbourhood of Folkstone, about a mile north of the town, and is, according to the survey published by the Board of Ordnance, 575 feet above the level of the sea. From the signal-house, above Folkstone, the depression of the cliff towards Dover, is very gentle. The hill on which Dover Castle stands, is, at its highest part near the Turnpike, 390 feet high*:—and if we suppose the cliff, where the castle walls terminate, to be 50 feet lower, which must be near the fact, we shall assume it to be in that place, 340 feet high. From this place, the cliff, generally speaking, declines in height gradually towards Deal, terminating about a mile from that place, and disappearing near

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* Geological Transactions, Vol. IV. p. 437.

Walmer Castle, beneath rubble and alluvial matter with which it is there covered to the depth of 15 or 20 feet.

In this long range of cliffs, which in many places forms an immediate barrier to the sea, it is not to be expected that every part should be equally accessible to investigation. Between Deal and Dover there is but little difficulty, nor for nearly half the way from Dover towards Folkstone; but in the latter half of that distance, an immense fall, or rather, it should seem, repeated falls have taken place; so that that part of the cliff of which the beds remain *in situ,* is, at its extremity beneath the signal-house, nearly a mile from the shore. The ruin lying between this cliff and the sea, for about three miles in length, affords scenery inferior in beauty to the "Undercliff" of the Isle of Wight, only because from its want of soil, it is less susceptible of cultivation; while from the same cause its grandeur is more striking. The greatest part of it, however, is sufficiently covered by herbage to have become a pasturage for cattle. The cliff, bounding this ruin towards the sea, is, from its position, evidently not *in situ*; and it is equally clear that the enormous masses of which it is composed, have fallen forward from near the summit of the cliff *in situ.* On the probable cause of this large ruin, I shall presently offer a few remarks.

In the less precipitous parts of the cliff, and particularly along that part of it, between which and the sea the ruin lies, it is in a considerable degree covered by herbage; which however does not prevail so greatly as to prevent the observation, that it is, throughout its whole length from Walmer Castle to Folkstone, very distinctly stratified; that the strata are numerous, regular, and perfectly defined, although from the nature of the cliff it is not possible every where to trace the stratification. The chalk with numerous flints, that with few flints, that without flints, and the grey chalk, all appear in the course of this range; and with them are connected some beds consisting almost wholly of organic remains, that have not, I believe, been described as occurring in other places. The strata lie in the following order, and are collectively about 820 feet thick.

1st. *The chalk with numerous flints;* it is about 350 feet thick, and may be thus divided;

I. With few organic remains, lying upon

II. A bed consisting chiefly of organic remains; in which numerous flints of peculiar forms are interspersed, and a few beds of flint run along it. This bed, I term, *the chalk with interspersed flints.*

2d. *The Chalk with few flints*; this stratum is about 130 feet thick.

3d. *The Chalk without flints* is 140 feet thick, and consists of

I. A stratum containing very numerous and thin beds of organic remains, 90 feet thick.

II. A stratum about 50 feet thick, with few organic remains.

4th. *The Grey Chalk*; this is estimated to be not less than 200 feet in thickness.

I propose to offer a few observations on the nature and stratification of these deposits, upon the flints of such as inclose them, on the stratification of the green sand of Folkstone, and on the blue marle overlying it in the neighbourhood of that place.

The accompanying sketch (Plate 1.) exhibits the range of these cliffs, from the signal-house above Folkstone to Walmer Castle. It is essential to be noticed, that they do not run in the same direction throughout their whole length. From the signal-house above Folkstone to the South Foreland, their general bearing is N.E. by E.; from the latter place the cliff is somewhat curved to St. Margaret's Bay; whence, to Walmer Castle, its direction is nearly due north.

Although the stratification is every where visible in a greater or less degree, it is best observed by tracing the junction of the chalk without flints, with the superincumbent bed of organic remains. This is visible with little interruption for five miles from the signal house above Folkstone to the foot of Shakspeare's Cliff, in which distance it dips only about 300 feet, in the direction of N.E. by N.

Proceeding from St. Margaret's Bay, the beds of flint appear to have nearly the same dip towards the north: whence it may be concluded that the chalk strata in the neighbourhood of Dover dip somewhat less than a degree towards a point between N. E. by E. and N.

CHALK WITH NUMEROUS FLINTS.

I. *With few Organic remains.*

The low range of cliff between Walmer Castle and St. Margaret's Bay, being about five miles long from north to south, consists altogether of the chalk with numerous flints. The rise of the cliff is gradual; its highest part being that immediately contiguous to St. Margaret's Bay, where it scarcely attains 200 feet in elevation. In consequence of its nearly uniform hardness from the base to the summit, it is almost precipitous, and suffers but little from decay or casual fall; but it is so low in some places, as at Kingsdown Bay for instance, as scarcely to exceed 20 feet above the beach. The beds of flints are frequent and thin, being on an average scarcely two feet apart; and the flints are obviously separate from each other. But a remarkable deviation from this general rule is observable immediately on the west of St. Margaret's Bay; where a continuous stratum of flint, about an inch and a half thick, rises from the beach, and is readily traced at least two miles from that bay: soon afterwards another rises which is about half an inch thick, and is visible for nearly a mile about 20 feet below the former.

Quitting St. Margaret's Bay for Dover, the chalk with numerous flints appears to rise gradually; forming, at the latter place, when viewed from the shore, apparently about one-third the whole height of that part of the cliff upon which the castle stands. Soon after leaving St. Margaret's Bay, the beds of flint begin to increase in distance and in thickness; in the latter respect they go on increasing to that part of the cliff which is immediately beneath the castle; where the thick beds, protruding at least two feet beyond the chalk, give rise to the idea of their consisting each of one mass of flint, but which their rugged edges, as viewed from below, seem to render at least doubtful. Some of these beds exceed a foot in thickness.

The chalk with numerous flints is again visible on the height west of the Castle, at a still greater elevation. That it forms the upper part of this height, was proved in making the extensive fortifications on its summit, as well as the openings a little beneath it, immediately below the citadel, which were intended for the reception of some part of the troops stationed at Dover during the war. These openings are in an unfinished and ruinous state, but they served to convince me of an interesting fact. Each of these four chambers is driven into the hill about 100 feet, and is perhaps 20 wide and 15 feet high; and in each, the only roof left to support the superincumbent chalk is *a bed of flint*. I do not say of flints, being convinced that the whole is one nearly-continuous, though not regularly tabular and evenly-disposed mass. The belief of the existence of this fact, in regard to at least many of the beds of flint in the upper chalk near Dover, was previously entertained, by observing the workmen on the shore cleave several blocks of chalk, each 8 or 10 feet square, close to the beds of flint passing through them; and in every instance, examination proved that the flint of each bed so exposed, was connected together: not that it formed one plane surface; but, though varying in thickness from 6 to 18 inches, the flint would, if it could be taken off whole, have exhibited occasional cavities, which, collectively, would have formed but a small proportion of the whole surface. A man who had been employed on this work during eighteen years, assured me that he had always observed the same fact.

Among the fragments of flint thrown aside, I noticed many having surfaces, evidently the consequences of fracture, that were opake and white; and as, on breaking these flints anew, they were always black internally, it seemed possible that this whiteness and opacity might be owing to the disintegration of the fractured surface by long exposure. The examination, however, of the beds of flint in these blocks of chalk, shewed the futility of this supposition; for the flint then exposed for the first time, was found to be cracked through in several places, from one cavity to the next: and the fractured surface was in every instance, more or less white and opake. Such a fracture seems explicable only by the supposition of a contraction having taken place in the flint while in its natural position. Nor does it appear to me at all improbable that a contraction had actually taken place. Flint newly disengaged from its natural bed, is much more brittle, requires a much lighter blow to break it, than flint that has been long exposed.* This may perhaps be owing to the moisture or water belonging to the flint in its natural state, but which it loses in great measure by the joint action of the air and sun.

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* The flint gravel used for mending the roads round London, is in some places providently taken from the pit some time before it is wanted, and exposed to the action of the air and sun: for this practice the alleged reason is, that it hardens; which, probably is the fact.

In some instances these naturally fractured surfaces, while yet imbedded in the chalk, were so close together as scarcely to admit the edge of a knife between them; in others they were half an inch apart, the intermediate space being filled with chalk. As the opake white substance, which in some cases only surrounded the edges of the fractured surface, did not project beyond the central part, still retaining the black colour of the internal part of the flint, it is clear that it was not a coating; but on the contrary, this circumstance seems to furnish strong, if not conclusive evidence of its being the consequence of disintegration, proceeding from causes that have not hitherto been explained. The alluvium of the surrounding country corroborates the supposition; every where it includes a multitude of fragments of flint, the broken surfaces of which always exhibit the same appearance of disintegration.

It is also I believe to the progress of disintegration that we are to ascribe the existence of the white opake coating by which the mass of every flinty stratum is more or less covered, while yet in its natural bed. In no instance did I observe any well defined line of separation between the flint and the opake coating, which not unfrequently is half an inch thick, and which by exposure to the sea becomes more compact, and hard enough to admit of a conchoidal fracture. Between its outer surface and the black flint, it is not uncommon to observe two or three thin bands of flint. If the white substance be the consequence of disintegration, it seems remarkable that these bands should have been thus left untouched. In order to ascertain the nature of the white substance surrounding the flint, I selected with care three portions. One from without the band—another from between the band and the flint—and the third of one in which there was no band. These my brother took with a view to determine what proportion of each consisted of lime, in case any should be found. The two first consisted wholly of siliceous matter; the last of 86 per cent. of silica and 14 of carbonate of lime. All the fragments were of a granular texture, and sufficiently hard to cut glass; each also left a whitish streak on the finger when rubbed with considerable pressure upon it; the last in the greatest degree.

Large fragments of striped flint of a grey colour are often discoverable among those which have been taken from the inferior beds in the upper chalk, but they frequently contain a nucleus of black flint, from which the grey stripes diverge as from a common centre.

Such flints as are interspersed in the chalk of the stratum with numerous flints, have usually some organic appearance. They are occasionally found in pear-shaped masses resembling the head of the alcyonium; sometimes in the form of nearly perfect spheres, which are solid, and do not commonly exceed half an inch in diameter, but are often much less. Others of no particular external form, have internal cellular or ramifying cavities which seem to indicate the same origin. Others again seem so decidedly to have been formed around sponges, that the flint has entered all the ramifications, the forms of which therefore remain.

It is not uncommon to find flints inclosing many of the shells observable in the chalk, and impressions of the few varieties of echinus common to that of Dover, the shells having been replaced by carbonate of lime, or the space they once occupied being left vacant; so that the internal cast of the shell, which is of flint, is in some cases connected with the surrounding mass by fine filaments of siliceous matter, arranged precisely in the order of the small perforations commonly visible in the shell, which therefore must have been formed while the shell was yet entire. Shells enclosed in flint are usually filled with the same substance; if only adhering to, or partially imbedded in it, they are always I believe filled with chalk.

About 40 feet below the summit of the cliff beneath the castle walls, lies a bed of a substance greatly resembling hard chalk marle, parallel to the beds of flint. It is about 18 inches thick, and is distinguishable from below by its being of a brownish yellow colour; and being harder than the chalk, it protrudes, presenting a rugged knotty surface. Such portions of it as fall, are collected by the lime-burner, who can convert them into lime only by using coal, instead of the ashes usually employed in the burning of chalk. Between this bed and the summit, a horizontal crevice is visible in the chalk, indicating the presence of a bed of soft chalk marle, but I had no opportunity of ascertaining the fact. Several other beds of hard chalk marle are visible in the upper chalk east of the castle, between the beds of flint.

II. *Bed of Organic Remains with interspersed Flints.*

When viewing the middle part of the cliff from its base beneath Dover castle, a singular roughness is visible. On ascending the green slope of some ruin, I found that it proceeded in a great degree from its having inclosed a vast multitude of organic bodies of various kinds, amongst which the remains of a few varieties of the echinus, and the ochreous marks of some varieties of sponge, were extremely frequent. In part also the ruggedness proceeded from a vast number of small flints irregularly interspersed through the bed, but which are not visible from below, because such parts of them as are exposed partake of the colour of the bed; for being separate, and mostly small, they do not commonly shew any fracture.

The numerous knotty projections of this part of the cliff are much harder than chalk commonly is, and than that in which they are imbedded. These remains of organic bodies do not lie in thin or separate beds; but form one large bed, occupying about one-third part of the whole height of the cliff beneath the castle, and in the centre of it.

The beds of flint lying immediately above this bed of organic remains, are less frequent and much thinner than those which are nearer to the summit of the cliff, and some beds of flint are visible among the organic remains. Indeed there does not appear any decided line of separation between this bed and the superincumbent chalk with numerous flints, and hence their junction is left undecided in the accompanying sketch of the cliff (Plate 1.): we may consider this bed, though it contains comparatively very few beds of flint, as the lower part of the chalk with numerous flints.

The whole bed has, from below, a greyish appearance; and by this it may be traced by the eye for at least two miles, dipping gently in its course, which terminates at the foot of the cliff just at St. Margaret's bay, four miles on the east of Dover. It may be seen along the cliff at the back of the town of Dover, and is visible west of it as forming the upper part of Shakspeare's cliff, and terminating on the summit of the cliff about two miles beyond it. Its run is discoverable, not by the exterior roughness alone, but also by the presence, near the bottom of it, of two parallel and rather thick beds of flint, which are about four feet apart, and may be seen along the whole course of the bed, as I have described it. Between these beds of flint, lies a thin bed of soft marle, which, becoming friable and crumbling away by exposure, leaves a crevice which accompanies the beds of flint, and which is visible for the greater part of their run; and a similar bed is visible parallel to it, about three feet beneath the lower bed of flint.

Several large masses that had fallen from this bed lay on the beach about a mile from Dover on the east; they had lately fallen, and as some of them had broken in the direction of the stratum, they afforded a good opportunity for observing the nature of the bed in its less exposed state, and of discovering whether it afforded any internal appearances tending to confirm the opinion I had formed of its nature, judging by the external roughnesses of this bed in the cliff. The newly broken parts shewed that the chalk of it is yellower internally than the superincumbent chalk with numerous flints, which is very white; they were also extremely rugged, and the more prominent parts were much harder than chalk commonly is. It was impossible to detach any of the numerous inequalities on these masses, without discovering some organic appearance. Some resembled vegetable stems coated with chalk of a different colour. In several instances, a cylindrical mass of whitish chalk, was surrounded by concentric coatings of the same substance of a darker colour, which sometimes amounted to ten in number. Ochreous traces of several varieties of sponge were likewise visible; but by far the greater number of the projecting portions consisted, when detached, of shapeless masses of chalk which were considerably hard, and which in some respect or other, either by exhibiting a slightly porous texture, or a striated surface, always induced the belief of organic origin. These striated portions are very hard within; the external striæ are sometimes very regular. Among other organic remains afforded by these masses, I extricated the cast, in chalk, of a small nautilus, which hitherto I believe has not been discovered in the upper chalk.

Such is the general hardness of this bed, that the workmen employed in blasting the cliff, and squaring the chalk for the purposes of the harbour, always leave untouched such masses of it as fall, except they belong to the lower part of the bed; which, containing fewer organic remains, is readily squared. The axe, when struck upon the chalk of the upper or middle part of this bed, returns a sound so exactly similar to that of striking upon flint, that the workman could only convince me that no flint was there, by clearing away what he had struck.

Throughout this bed of organic remains, numerous thin veins of a grey colour run, generally speaking, parallel with the stratum. These veins however, are not straight, but undulate, terminating imperceptibly, being again renewed a little above or below. Some masses that had been split by the workmen along these veins, gave the opportunity of examining their nature, and it became very evident that they originated in the presence of some organized body. It was easy to detach from every part of the newly exposed surface, hard conical masses, striated from the summit to the base by lines of a dirty brown colour, which were glossy and moist: and where the continuity of the cone was accidentally interrupted by fracture on the side, the same appearance was discoverable within. It was evident that the nearly horizontal part of these grey veins connected together the neighbouring conical masses. Wherever a flint or a shell was imbedded in contact with one of these veins, it exhibited superficially the same striated appearance as the conical masses of chalk.

The flints interspersed through this bed of organic remains are generally of remarkable forms, and shew either internal or external evidence of their having been formed in or upon some organized body. They are not uncommonly of a nearly spherical shape; and when solid, there is uniformly, as far as my observation goes, a small indented circle upon each: when not solid, they always contained a nucleus having the appearance of a sponge of the same shape as the flint: these rarely exceed an inch in diameter. Others are cylindrical, and inclose another flint of the same form; others (and they are numerous) are conical, having a flat base, around which is always indented an oval, within which there is sometimes the indented mark of a sponge: some of these are solid, others are lined with tuberculated chalcedony of a bluish aspect; these are about two inches high: a thin lining of blue chalcedony, which is extremely greedy of moisture, is by no means uncommon within some of the flints of this bed. There are others very common to it, whose external marks, consisting either of deep indentations or small rugged projections, bespeak the probability of their formation being in some way or other connected with organic matter. But there are other flints which it is not easy to describe. They inclose a cylindrical flint, resembling the stem or a branch of a vegetable, which, passing along the mass, is visible at each end, where sometimes it divides into numerous little branches: another of the same description crosses it, giving to the external flint a peculiar shape, and inducing the belief that it must have been deposited around some organic substance, of which the form is preserved by the internal ramifications. The whole of these flints are numerous in this bed of organic remains; but I did not discover any resembling them in form and character in any other part of the chalk.

The numerous shells of the echinus, or rather the calcareous spar which has replaced them, are almost always whole; rarely was one visible that had suffered depression; but the chalk with which they are filled, instead of being finer than that in which they lie, as is frequently the case in the echini of the upper part of the chalk with numerous flints, is on the contrary much coarser and of a somewhat sandy aspect.

This bed of organic remains with interspersed flints, is separated from the bed on which it lies, the chalk with few flints, by a bed of marle two or three inches thick, which lies about 15 feet below the two beds of flint mentioned at p. 25. The exterior roughness of the bed is however far less, and the interspersed flints are fewer, for 10 or 12 feet of its lowest part, than in the middle or upper part of it.

CHALK WITH FEW FLINTS.

The chalk of this stratum is soft and white, though not of so pure a white as that with numerous flints. It contains a few thin beds of organic remains, which, arguing from the ochreous characters that are frequently visible, may be considered as being chiefly of sponges: these beds are most frequent and determinate just below the thin bed of chalk marle forming the separation between this and the superincumbent stratum. About 20 feet below that bed, two somewhat thicker beds of soft chalk marle run parallel with each other and with the line of separation, and at about three feet apart. As the marle shivers by exposure, these two beds may readily be traced along the cliff as crevices, rising from beneath the beach about two miles east of Dover, and pursuing their course without interruption, except such as is caused by the occasional falls of the cliff, quite to its termination beneath the castle: they are also very visible in some parts of the cliff above the town, where its surface is exposed. Traces of them may be seen on Shakspeare's cliff; but from their position in it, and in that further west, as well as from the nature of the cliff itself, which is too precipitous to be easy of access, they cannot readily be traced along it.

The marle of these beds commonly shivers by exposure in a direction parallel with the stratum; but undulating grey veins pass along it, and here and there may be extricated from them small conical masses in every respect similar to those which have already been mentioned in page 27.

Just beneath the thin bed of marle forming the line of stratification, two thin beds of separate flints are very visible, but not lying in the same manner as those belonging even to the thinnest beds in the chalk with numerous flints; their largest surfaces are not parallel with the stratum; but on the contrary, as they lie in every direction, they do not form an even line in regard to each other; and this is the general character of the few thin beds of flints occurring in this stratum, which do not continue for any considerable distance. Flints sometimes lie in the occasional thin beds of sponges which appear on the face of the cliff, and sometimes exhibit impressions of them on the surface. The flints interspersed in the chalk of this stratum are frequently cylindrical, and are sometimes in the form of the bulbous head of the alcyonium, or in shapes resembling vegetable stems: such flints I have observed here and there of more than two feet in length and scarcely exceeding half an inch in diameter, but they were always cracked across in several places.

The grey veins so numerous in the lower part of the superior stratum, are almost as frequent in this, but prevail most just above or below the thin beds of organic remains and of flints above-mentioned, and in the neighbourhood of those numerous and nearly parallel crevices which are so many indications of regular stratification.

The ammonite has hitherto, I believe, been supposed to be first visible in the under chalk, or that without flints. A large one lies in the cliff about a mile eastward from Dover, nearly in a horizontal position, and just above a bed of flints which runs for some distance only a foot or two above the base of the cliff, and there are many interspersed flints within a few feet all around it. Two other ammonites from 12 to 18 inches in diameter, are visible at low water, in chalk, belonging evidently to that with few flints, but whether it be in situ or not, it is difficult to determine. One of them is distinctly oval.

About a mile and a half east of Dover, and near the place at which this stratum rises from the beach, I found the cast of a nautilus in it.

Iron pyrites is by no means uncommon; it usually occurs in globular masses, coated by crystals having the form of the octohedron, which sometimes are attached to a flint: in one instance it was observed filling up the cracks in one. One mass had been formed around a terebratula, of which the shell, filled by pyrites remained, but in a friable state. This stratum yielded to my search pectinites, terebratulæ, and the palates and vertebræ of fishes. A nearly perfect specimen of one species of the striated shell or inoceramus, perhaps the only one hitherto discovered, was found by the workmen employed in squaring the chalk: it was nearly filled with flint, and was partially imbedded in it.

Several excursions along the cliff between Dover and Folkstone, both at its base and on its summit, as well as the occasional opportunity of ascending or descending it, enabled me at length satisfactorily to discern the nature of the connexion of the chalk with few flints, with that on which it reposes, namely, a thick stratum without flints, enclosing numerous thin beds of organic remains, lying nearly close together.

A thin bed of soft marle lies between these strata. It may be readily traced along the cliff, as a crevice, for a considerable distance, but is most conveniently viewed while ascending Shakspeare's cliff from the town. Flints are here and there visible a few feet above this bed of marle, but not one was discoverable below it. Between this and a similar bed of marle nine or ten feet beneath it, are to be seen many of those thin beds of organic remains, which are characteristic of the stratum on which the chalk with few flints reposes. Both these beds of marle are also seen in the most elevated part of the low cliff, between Shakspeare's cliff and the town of Dover.

CHALK WITHOUT FLINTS.

I. *Stratum containing numerous thin beds of Organic Remains.*

This stratum, both internally and after exposure, is yellowish and without flints; for not one was visible in it, either in the cliff, or in the numerous masses lying at its base: in hardness, it exceeds the chalk with interspersed flints.

The low cliff immediately contiguous to Dover on the west, consists wholly of the chalk of this stratum, except the summit of its most elevated part, which consists of the chalk with few flints; but in this place it does not so decidedly appear to consist of a number of thin beds of organic remains, as it does after rising from the beach at Shakspeare's cliff; nevertheless it manifestly consists of a vast accumulation of organic exuviæ. This stratum may be traced without interruption for nearly four miles; but the summit of the cliff between Dover and Folkstone, for the latter half of the way, quite to its termination near the signal house above the latter place, decidedly belongs to the chalk with few flints: a close examination of it discovers here and there a few interspersed flints, and a single bed of them is visible about 40 feet below the summit, just half way between the two places. Wherever a path is practicable, the cliff is so sloping as to be covered with a verdure which prevents an accurate discovery of the stratification by ascending it, and it cannot always be seen from either above or below.

The external roughness occasioned by the numerous thin beds of organic remains in this stratum, is far less considerable than that of the chalk with interspersed flints. Still the same appearance of sponges is visible after long exposure, but they lie closer together, and when detached are less. The few are not unfrequently separated by the remains of shells, so small as to be nearly in a state of comminution, a large proportion of them being varieties of the striated shell or inoceramus. The two varieties of the echinus so common in the chalk with interspersed flints are occasionally seen in this bed, but are less numerous. Ammonites from 12 to 18 inches in diameter and of a circular form are not uncommon: I saw several, all of which lay parallel to the strata. Though the thin beds of organic matter are nearly in contact in the lower part of the stratum, they are more separate in the upper part of it.

Through one of the many large masses lying on the shore, a bed about nine inches thick took its course, consisting of remains essentially differing from the rest. It consisted chiefly of ramose appearances about half an inch in diameter, and the masses detached from it greatly resembled those of the alcyonium visible in the sand of the Isle of Wight, described by fig. 12, pl. 29. vol. 2, of the Geological Transactions.

In this stratum I did not perceive any traces of pyrites, so common in other parts of the cliff. It includes grey veins similar to those of the chalk with interspersed flints and of that with few flints, but they are far less numerous, and though the organic remains which occasion them are similar, they are much smaller.

II. *Chalk without Flints, and with few Organic remains.*

This stratum rises immediately at that part of the base of Shakspeare's Cliff which is nearest to Dover, and is separated from the stratum containing numerous beds of organic remains, which reposes on it, by a bed of soft marle. As this marle, like all the others of the same nature that are visible in these cliffs, becomes friable and falls away by exposure, it serves as a certain guide to the stratification, and may be seen with little interruption for more than half the way to the signal-house above Folkstone, and at intervals for the other half; so that the connexion of the two strata may be traced for five miles without difficulty. Without this aid, however, there could only have existed such hindrance as naturally arises from occasional verdure on the face of the less precipitous parts of the cliff, being those above the undercliff: for the chalk of the two strata differs greatly in appearance. That of the stratum I am describing is soft, and even white in comparison of that which lies upon it, though not so white as the chalk with few flints; and for six feet beneath the bed of marle, is of so sandy a texture occasionally, as to be even friable, but here and there it assumes the appearance and compactness of a sandstone.

The nearly horizontal crevices in other parts of the cliff appear to be nearly parallel with the stratification; but in this, the crevices differ from that position, and are even in a transverse direction; those that are nearly vertical are numerous, giving to the chalk in many places, an angular appearance, not common to any other parts of the cliff. It runs along the base of the cliff for somewhat less than half a mile, and in that space, affords, even on a close inspection, the traces of but few organic remains.

It incloses masses of pyrites, some of which are crystallized externally in the form of the octohedron, but their general form is spherical. Others, and they are not uncommon, are in the form of cylinders, rounded at each termination, to which there is frequently a short stem attached; the whole having the appearance of organic origin. When broken across, they are always found to radiate from the centre.

Here and there appears a small bed of sponges, of which the ochreous forms are visible; but this stratum contains none of the grey veins so numerous in the superincumbent strata. It is about 50 feet thick.

GREY CHALK.

The grey chalk differs from the strata reposing on it, in being softer. It varies considerably in different places, in respect of colour and texture; being much more sandy and less compact than in others. A fair specimen of it yielded to my brother, by analysis, 82 per cent. of carbonate of lime, and 18 of silex and alumine, chiefly of the former, and a trace of the oxide of iron.

It first rises from the beach at the foot of the low cliff contiguous on the west to that which is known by the name of Shakspeare's; but its separation from the chalk without flints is not at that place perfectly defined. In less than a quarter of a mile beyond the place at which it rises from the beach, the two strata are very distinct; the white being separated from the grey by some very thin beds of a sandy appearance and yellowish colour. As the grey chalk rises, its colour becomes deeper, and it is here and there so extremely soft, that the rain in descending the cliff, has carried down and deposited at its base considerable quantities. It is in these places particularly, that beds of sandstone from 1 to 4 or 5 inches thick, and extremely hard, take their course parallel with the stratum for a short distance, projecting beyond the face of the cliff from a few inches to two or three feet. A fan-shaped projection of this kind overhangs a copious stream of pure water issuing from the grey chalk, termed Lidden spout, protruding beyond the surface of the cliff, not less than five feet.

Not a flint is visible in this bed: its organic appearances are numerous, but do not differ considerably from those of the superior strata. Along the crevices running parallel with the stratification, the chalk is commonly of a deeper grey than the bed in general, and incloses some still darker appearances of ramification, resembling in their general form some varieties of broad-leaved fuci, which are somewhat softer than the chalk in which they are imbedded. The reverse of this is occasionally observable in the more solid parts of this chalk, and where its colour is of a lighter grey; for there it is sometimes traversed in every direction by very numerous and small ramifications of a colour still lighter. The remains of the echinus are numerous, and their shells are replaced by carbonate of lime of a grey colour: every one I saw had not only suffered depression, but the shell was also in every instance broken; a circumstance which is the more remarkable, as it is rarely discoverable in any of the superior strata.

Small masses of pyrites are very common, and there are some of singular forms. Thin strings of it, sometimes ramified, the branches terminating in a point, are very numerous; but sometimes on the contrary they are terminated by a spherical bulb, or by one that is elongated and resembling the head of the alcyonium, but very small; these are generally hollow. A remarkable crystallization of pyrites is also very common. A string of octohedrons piled with considerable regularity on each other, and above an inch in length, is crossed by another similar to it,—the termination of each being the quadrangular pyramid of an octohedron:—these again are crossed at right angles by another, which is terminated in like manner, so that the three have one common centre: giving to the whole the appearance of the commencing crystallization, or the skeleton, of one large octohedron. Thin beds of sponges occasionally appear, their remains being either ochreous, or of a lighter colour than the chalk itself; but these are visible only when the stratum has risen considerably, and near to the beginning of the undercliff. Near the stream called Lidden Spout, I found the cast of a large nautilus in grey chalk, but much harder than that of the stratum.

GREEN SAND AND BLUE MARLE.

The investigation of the chalk cliffs being my primary object, little attention was given to the green sand. The opportunity for observing its dip was however too favorable for it to be wholly omitted. But my interest was chiefly excited in the neighbourhood of Folkstone, by a considerable deposit of a marly substance overlying the sand at Copt Point, and which in its natural bed is of a bluish colour, and in some places so moist, as to be incapable of bearing the weight of a man, except in dry weather, which hardens the surface, cracking it in every direction. My brother found that by submitting 100 grains of this marle to the action of acid, 13 were lost, indicating the presence of nearly 30 per cent. of carbonate of lime.

The town of Folkstone is built upon the green sand, which is known in many parts of England mediately or immediately to underlie the chalk. It incloses beds of sandstone. The cliffs on the east of the town, may be in some places 80 or 90 feet high, the upper part of which, for a considerable distance from their termination at Copt Point consists of the blue marle, which in some parts may be from 40 to 50 feet thick.

The run of this cliff is not quite parallel with that of the chalk cliffs between the signal-house and Dover. The dip of the sandstone lying in the green sand is about the same as that of the chalk, as it appears on the surface of those cliffs.

Although from the similarity of this bed of marle to that which is observed in other places to lie between the chalk and green sand, there can be no doubt that it passes under the chalk, yet it is not easy to discover it so interposed.

The chalk cliff turns southward towards Folkstone near the signal-house, presenting a ridge which slopes rapidly; so that the chalk is not seen in situ quite so far down as the nearest of the three Martello towers. Below that place, all is ruin for a considerable part of the way to Copt Point; the colour of the chalk being lost by insensible degrees in the blue marle, and both together occupy the descent to the shore for a short distance. Between the second Martello tower and the shore, the descent chiefly consists of the blue marle, which continues to Copt Point; and it can scarcely be doubted that the high ground between the shore east of the Martello towers, and the Canterbury road, and perhaps still further west, consists mainly of the blue marle, which is visible soon after that road has branched from the road to Dover, in a field on the right, from which the alluvium has been removed in search of flints for mending the road. It also appears in a field at the foot of some high chalk ground behind a small farm house near the second of the Martello towers; where a spring of pure water issues from beneath the chalk, and running over the marle makes its way down the descent, consisting chiefly of chalk ruin, into the sea.

The perishable nature of the marle seems to have been the chief cause of the immense ruin lying beneath the cliff, at the extremity of which the signal-house stands. For the sea, having washed away the marle which formed the base of the cliff, the upper part, losing its support, has fallen down. The cliffs now forming an immediate barrier to the sea, have chiefly fallen from the stratum containing numerous beds of organic remains.*

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* Since writing the foregoing, I have received from my friend L. W. Dillwyn, Esq. of Pentlergare near Swansea, a letter, containing the following account of a sudden rise of this marle in the Bay, and opposite to the undercliff. ‘ I promised you to endeavour to recollect and give you my observations on a small island which sprung out suddenly from the sea, about a mile to the eastward of Copt Point between Dover and Folkstone. I well remember, that whilst botanizing in that neighbourhood somewhere about the year 1799, a fisherman told me that a gold mine had sprung out of the sea a night or two before, and being puzzled to imagine his meaning, I begged him to conduct me to the spot, which he said was accessible at low water. As nearly as I can recollect, I found it to be about a acre or an acre and half in extent, and from eight to ten feet high, and so close to low-water-mark, as to be only accessible at spring tides. It was composed of a soft muddy marle filled with nodules of remarkably brilliant mundic, and containing numerous small nautili, which were more richly coated with nacre, and by far more irridescent than any others I had ever seen. On mentioning this island to my worthy friend the late Rev. John Lyons of Dover, he told me he thought he could account for its formation, and with a view to confirm an opinion which he had several years before communicated to the Royal Society (See Phil. Trans. for 1786), he accompanied me to the spot. Between the island and the chalk cliff in situ, and at the base of the latter, on the undercliff, we found rather a large morassy pool of fresh water. From this pool a considerable stream appeared to run underground in that direction, and to burst out again from the sands close to the island. I cannot sufficiently recollect the particulars of our observations, but as on examination we found that there had been a sinking of part of the cliff abruptly, I perfectly remember our conclusion was, that the slip of the cliff had occasioned a body of chalk to press suddenly and with great force upon a quantity of marle which had become softened by an underground stream, and forced it through the channel, so as to form an island at its mouth. Mr. Lyons had no doubt that it was the same stream which he told me he had seen losing itself gradually in the soil at some considerable distance inland, and which by loosening and softening an understratum of marle, had thus occasioned the superincumbent chalk to give way. Two or perhaps three years afterwards, I again visited the island, but it had then become, by the action of the waves, greatly reduced in height; and, if I remember right, the marle which remained was nearly indurated. I have some of the above mentioned nautili, but they have lost most of their beautiful nacre, and owing to the late removal of my cabinets, I now hardly know where, nor have I time

Since the grey chalk assumes a darker colour as more of the stratum rises to view, it seems probable that it passes into the blue marle by insensible degrees. There is however a great difference in the organic remains of these two strata; at least in their mechanical texture; those shells which were nacreous when recent, rarely shew the pearly lustre in the grey chalk, while those which are found in certain parts of the blue marle are rarely without it: but this is generally the case with shells originally nacreous, which are found in beds of clay; the close texture of the clay having protected them from the action of air and moisture.

Among the numerous fragments of fossil wood imbedded in this marle, but which chiefly lie on the green sand, some are several inches in diameter, and still retain the woody fibre: they are mostly enveloped in, or the interstices of their outer part are filled with pyrites, which is commonly in a state of decomposition, one of the consequences of which is the formation of selenite in crystals, which are often well defined. These are either attached to the fossil wood, or lie imbedded near it. Some small masses of a substance having the appearance of bone in a fossil state have been discovered.

By far the greater proportion of those shells of which the nacre is extremely brilliant and sometimes even irridescent, are inclosed in more compact masses of a lighter and more uniform grey colour than the marle itself. On submitting 100 parts of this substance to the action of acid, my brother found that 3 were lost, indicating the presence of 7 per cent. of carbonate of lime.

to look for them. In the course of a month or two, I however hope to send you a few specimens, and shall be most happy if the Geological Society should find them worth their acceptance.

I remain, &c.

Pentlergare, Nov. 15th, 1817. L. W. Dillwyn.

There is no doubt that this deposit is altogether analogous to that underlying the chalk at Malling in Kent, in Cambridgeshire, and Oxfordshire, and in the latter counties provincially termed *gault.* In the collection of the Society specimens of the beds and of the fossils of Folkstone and Cambridgeshire are arranged together as being identical.

ALLUVIUM.

The summit of the chalk cliff near the signal-house is covered by a sand of a bright red colour of various shades, and from 10 to 20, and even in some places, 30 feet in thickness. Here and there it is intermixed with clay, when the red colour which it assumes in its purer state is less brilliant. Here and there also small glistening particles are scattered through the sand, having all the appearance of being scales of mica that have suffered by removal from their original situation, the edges being ill-defined and even ragged. Masses of sandstone, consisting of minute, rounded, and transparent particles of siliceous matter, agglutinated by an ochreous cement of a deep brown colour, lie in the sand, but in one place only, which is very near the signal-house, with any appearance of stratification; but even in this instance, it is too obscure for determination.

The sand continues of the varying thickness above mentioned, for at least half the way to Dover; after which it sensibly decreases, and is nearly lost before we arrive at Shakspeare's Cliff, except that occasionally the thin alluvium lying on that part of the cliff is somewhat coloured by it. The whole surface of the country, for a considerable distance north and north-west of the signal-house, consists of this sand more or less intermingled with clay. Flints are every where imbedded in it; but are visible principally as forming a thick but irregular bed lying on the chalk, at the bottom of the sand, and of course are not in situ. These flints perfectly resemble those belonging to the chalk with numerous flints, as well as that with interspersed flints. Those lying at the bottom of the sand, which of course is intermingled with them, are ochreous externally, but are not very much broken: some were incrusted by iron in the state of radiated black hæmatites. This deposit of flints every where accompanies the red sand along the cliff, and appears to be thickest where the sand is deepest: but this sand is not visible for any considerable distance on the descent of the hill west of the signal-house, and down which the road from Dover to Folkstone descends; nor on any part of the cliff east of Dover; nor are flints bearing the same characters, that is to say, which are whole or nearly so, to be seen any where in the alluvium covering the chalk, except beneath the red sand.

This considerable deposit of flints bears evidence that, at some remote period, a vast destruction of the upper chalk took place, from causes which it is now impossible to ascertain. We may, however, venture to conjecture, that these cliffs were once covered by the chalk with numerous flints, and that it was swept away by one of those deluges, which there is every reason for believing to have been numerous as well as extensive. Every where along these cliffs is to be seen unquestionable evidence that such a deposit of chalk has suffered extensive ruin by water. In receding from the signal-house towards Dover, the red sand is covered by a still newer alluvium, in which lie imbedded small rounded masses of chalk, from the size of a pea to that of a walnut, together with small fragments of flints and of iron-stone; and this alluvium, when the red sand no longer appears, commonly lies on chalk ruin, sometimes containing flints, and which, in the lower parts of the cliffs, is often of considerable thickness. It occurs more or less in all such places, from the termination of the red sand, about half way between Folkstone and Dover, quite to the extent of the cliff near Walmer Castle. On the low cliff, for instance S. W. of Dover, the chalk rubble is in some parts fifteen feet thick, and is covered by alluvium holding flints of about the same thickness. On the higher parts of the cliff, however, the rubble is rarely visible; and the newer alluvium, including Shakspeare's Cliff to Kingsdown Bay, rarely exceeds two feet in thickness; while on those parts of the summits of the cliff, of which the descent is quickest, as well as on the hill on which Dover Castle is built, and on the elevations for some miles east of it, the alluvium is rarely a foot thick. Descending by the Dover road to Folkstone from the signal-house, the alluvium on each side becomes less and less tinged with the red sand; and before reaching the first chalk opening, it assumes the character of the newer alluvium, enclosing rounded masses of chalk and fragments of flints, and is very thin. Large and numerous fragments of flint are turned up by the plough in the cultivated land forming a gentle declivity towards Folkstone, and commencing at the bottom of the hollow above which the road descends:—but nearer to Folkstone, in the lower parts of this declivity, the alluvium is very thick. In the field, for instance, which has already been mentioned as being of the blue marle covered by alluvium, it is nearly ten feet thick, and consists of clay intermingled with chalk, fragments of flint, of which the surfaces are in a disintegrated state, and fragments of ironstone. The same sort of alluvial deposit seems to cover all the intermediate land between that place and Copt Point, wherever there is an opening, and it prevails along the summit of the blue marle from that point to Folkstone.

Along the summit of the cliff between the signal-house and Dover, and indeed wherever any considerable opening appears in the chalk, deep indentations or gullies are visible in it, which are filled with clay, and which have, as it appears to me with great probability, been attributed to the action of water on its surface.* Even when these appear beneath the sand, they are commonly filled with clay, occasionally inclosing flints, the surfaces of which are ochreous. They are not, however, usually imbedded promiscuously in the clay, but are more commonly arranged close to the chalk, forming a thin bed in the form of the hollow which once existed in it. This arrangement is visible in almost every instance. One of these gullies, which appears on the side of the road, about half way between the signal-house and the turn of the Dover road towards Folkstone, deserves mention. The road is cut through it to the depth of about fourteen feet: the fissure holding the clay is visible to that depth, but is deeper, and it is about four feet wide. A few feet from the summit, it narrows so as to appear little more than a string of clay for about a foot, when it begins to open again, but not in a line with the upper part; and the lines of connexion between the upper and lower parts are contorted and curved.

There is one circumstance regarding the upper part of the cliffs that merits notice. Every where along them, and even in the openings beneath the surface inland, except where the chalk with numerous flints prevails, the chalk appears in small angular masses, from an inch or two to a few inches in length and breadth, and this appearance holds for a few feet under the surface; near to which, it it observable, that the angular masses are always the least. In fact, the aspect is what may be termed shattery, and it prevails in so great a degree in the three openings near the turn of the Dover road below the signal-house, and on the side of the conical hill, near to which the road to Canterbury passes, that the chalk there had, at first sight, the appearance of not being in situ.

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* Geological Transactions, Vol. I, page 176.

On comparing accounts of different parts of our great chalk deposit, it clearly appears that there is not every where a perfect uniformity in its strata. No such beds of organic remains as accompany the chalk with numerous flints and that without flints near Dover, have been described as occuring in other places. The chalk marle underlying the chalk without flints in the Isle of Wight* is wanting near Dover; for the grey chalk underlying it near that place differs from the chalk marle in its general colour, in not pulverizing by exposure to air, or shivering by the action of frost; nor does it contain nodules or beds of greater induration, except the thin beds of sandstone already mentioned: moreover, it contains nearly the same organic remains as are found in the chalk above it, while the fossils of the chalk marle in the Isle of Wight, differ from those found in the chalk in every instance but one†. The beds of sandstone occuring in the grey chalk of Dover, many however prove it to be analogous with the grey chalk of Cambridgeshire, although it is described by Professor Hailstone as being harder than common chalk, while the grey chalk of Dover is softer. If indeed they be analogous, the chalk without flints is wanting in Cambridgeshire, for the flinty chalk there reposes on the grey chalk.‡

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* Geological Transactions, Vol. II. p. 264.

† Ibid Vol. I. p. 179.

‡ Ibid Vol. III. p. 243.

In the wolds of Lincolnshire that which is generally uppermost is white, and contains beds of flints. The lower is red. They are regularly stratified; and the latter rests upon a brown pebbly sand without organic remains, consisting of quartz and oxide of iron.*

In the preceding pages, allusion has occasionally been made to certain of the organic remains which I discovered in the various beds and strata composing the cliffs I have attempted to describe. These remains being numerous, and some of them not having heretofore been noticed as occurring in chalk, I have prevailed on J. Parkinson, Esq. the author of "The Remains of a former World," &c. to receive the whole, together with an additional number from the green sand and blue marle, collected by my friend Luke Howard, and by him presented to me, with a view to his preparing a description of them for the Geological Society. To this I was impelled, not only because it secured a more faithful description of them than could otherwise be obtained, but also on account of my own inability to perform that task, never having given particular attention to this interesting branch of geological investigation. I am far from believing that I was able, during a short stay at Dover, to discover all the varieties of fossils enclosed in the cliffs in its neighbourhood, having found some that were new to me in the last hour of my search. I shall hereafter offer to the acceptance of the Geological Society, all such from amongst them, as may be worthy of a place in its museum.

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* Geological Transactions, Vol. III. p. 394.

APPENDIX;

Containing some account of the Chalk Cliffs, &c. on the Coast of France, opposite to Dover.

THE appearance of a darkish line, extending with a gentle dip towards the east, along the middle of the chalk cliff forming Cape Blanc Nez on the coast of France opposite to Dover, induced the suspicion that it might be owing to the existence of a bed having some analogy to one of those in the neighbourhood of Dover, which have been described as consisting chiefly of organic remains. Another and a darker line, the nature of which was not at first suspected, was afterwards observed by my friend S. Woods, Esq. Member of the Society, by the assistance of a glass. These circumstances, together with some anxiety to ascertain whether the chalk of the opposite shore possesses the characteristic appearances of that in the neighbourhood of Dover, determined me to visit and examine it with attention.

Between Calais and Sangate, a village five miles on the south-west, the boundary of the sea consists of a range of low banks of white sand. At the western termination of the latter place, the cliff begins to rise, and assumes a new character; consisting for a considerable distance of fragments of chalk-flint, and rounded masses of sandstone similar to those found in the alluvium covering the chalk and blue marle near Folkstone, imbedded in a sandy clay of a reddish brown colour. In less than a furlong this kind of deposit is confined to the summit of the rising cliff, which consists beneath of sand lying in thin beds of different colours, rising conformably, or nearly so, with the rise of the cliff; but the general tint of the mass is greenish. The probability that this sand may belong to the plastic clay formation occurred to me, but I discovered nothing beyond the general appearance of the sand to strengthen the suspicion.

The junction of this sand with the chalk is not visible, being covered with loose sand and alluvial matter. The one however seems to abut against the other, as shewn in the accompanying sketch (Pl. 1. Fig. 2).

The chalk which first appears at the base of the cliff, after passing the sand, is without flints, and exhibits but few traces of organic remains; it perfectly resembles that which rises at the foot of Shakspeare's cliff near Dover in softness and in sandiness of aspect, especially just below its junction with a superincumbent stratum, consisting of thin beds of organic remains. This stratum resembles so closely that which lies in the same position on the west of Dover, that no difference in its aspect or composition is visible; and these two beds are in each place separated by a bed of soft chalk marle, which, having fallen out by exposure, has left a perfectly defined crevice along the cliff. It is this stratum of organic remains which is occasionally observable from Dover, as a darkish line, even without a glass.

Grey chalk soon after rises to view from beneath the chalk without flints or organic remains, and forms the dark line at the base of the cliff observed by S. Woods, Esq. from near Dover: it has all the characters of that which underlies a similar bed on the west of that place. The grey chalk forms the base of the principal part of Cape Blanc Nez, and of the centre of Petit Blanc Nez. A blue marle forms the base of the latter. The junction of the marle with the grey chalk is well defined. The marle has a perfect resemblance to that which forms the summit of the cliff between Copt Point and Folkstone, contains similar organic remains in great plenty, together with so vast a quantity of iron pyrites, that works have been established near St. Pot for the manufacture of green vitriol.

Small masses of a green sandstone, similar to that lying in the sand which forms the base of the cliff between Copt Point and Folkstone, are scattered along the shore at the foot of the chalk cliff. I expected therefore to find it underlying the blue marle. But the latter, owing in part to the looseness of its texture in dry weather, in part also perhaps to its having been turned over in search of iron pyrites for the vitriol works, forms the whole of the low bank near St. Pot; between that bank, however, and the sea at low water, lies a large assemblage of green sandstone rocks, many of which appear to be in situ; so that no doubt can be entertained of its underlying the blue marle. The latter terminates near St. Pot, and is succeeded by a loose white siliceous sand for a considerable distance on the west; but the sand and marle are for some little way intermingled.

While viewing Blanc Nez from the base, it is readily observed, that the stratum consisting of numerous thin beds of organic remains which forms its centre, is separated from the superincumbent stratum, which is much whiter and softer, and on which few traces of organic exuviæ appear, by a thin crevice, indicating the presence of a bed of chalk-marle. In this softer chalk, dispersed flints are visible, and are readily cognizable by the assistance of a glass.

This stratum possesses altogether the characters of the chalk with few flints, which appears in the same relative position in the cliff on the west of Dover.

About twenty feet below the summit of the eastern of the two elevations composing Cape Blanc Nez, run two parallel beds of flints, three or four feet apart: between them there is a crevice, and another about three feet below the lowest bed of flints. In these respects the summit perfectly resembles that of Shakspeare's cliff, and of the still more elevated cliff on the west of it (see p. 25.) The chalk of the summit of Blanc Nez is however the whitest of the two; but as, from the roughness of the exposed surface, it manifestly consists chiefly of organic remains, I cannot hesitate to consider it as analogous to the chalk with interspersed flints, which forms the summit of the elevated cliffs next to Dover on the west; especially since the crevices left by the falling out of the chalk-marle, are the same in number and position in both places (see p. 25), and since also another crevice runs a few feet below, corresponding with that noticed at p. 29 as being the boundary between the chalk with interspersed flints and that with few flints. It ought, however, to be noticed, that the two remarkable crevices which are visible near Dover, in the upper part of the chalk with few flints, (see p. 29,) are not observable in that of Cape Blanc Nez.

On comparing the sketch of the cliff on the west of Shakspeare's near Dover, with that of the eastern part of Cape Blanc Nez, it will be seen that they are composed of the same varieties of chalk; and on comparing the whole of both sketches, it will be found that the three miles of coast, commencing about one mile on the west of Sangatte to St. Pot, consist of the same deposits as those which constitute the long range of coast between Deal and Folkstone;

except that the upper part of the chalk with numerous flints is not visible in the former. The dip of the strata appears in both cases to be the same.

On reviewing the many remarkable points of agreement between the cliffs on each side the Straits of Dover, it seems a supposition too reasonable to be ranked among mere hypotheses, that they were once united, and that they were separated at some very remote period by an irruption of the sea, which in all probability washed away the connecting mass; for the unreasonableness of the popular notion that the two countries were simply rent asunder by some sudden convulsion, will become apparent, when it is further stated, that the chalk without flints on the west of Dover is not less than fifty feet in thickness, while that of Cape Blanc Nez is scarcely thirty feet thick, and that each of the overlying strata at the latter place, is thinner than those near Dover, in about the same proportion; so that the height of the cliffs on the opposite shores is very different;—that immediately on the west of Shakspeare's being not less than 500 feet, while that of Cape Blanc Nez does not exceed 300 feet in height. Hence, supposing the two countries to have been once united, it may be assumed that the several chalk strata became gradually thinner in approaching that part which now constitutes cliffs on the coast of France: hence also, it may be concluded that the country in the neighbourhood of Calais, once constituted a part of that tract which is now termed the chalk basin of London.

V. *Remarks on the Fossils collected by Mr. Phillips near Dover and Folkstone.*[*]

By JAMES PARKINSON, Esq.

MEMBER OF THE GEOLOGICAL SOCIETY.

[Read January 16 and February 20, 1818.]

MY object in the following remarks is to give a catalogue of the fossils collected by Mr. Phillips, and to offer at the same time such desultory observations as the fossils themselves may suggest. As the search for Organic remains was confined to the cliff, the following list must not be considered as a general catalogue of the numerous fossils which these strata are known to contain.

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[*] I take this opportunity of correcting some opinions which I formerly advanced in my paper on the strata in the neighbourhood of London, published in the first volume of the Transactions of the Geological Society. By observing similar pebbles congregated in particular spots, and differing from those of other situations, as the pebbles of Woolwich, of the Middlesex gravel, of the Hertfordshire puddingstone, &c., I had been led to conclude, that they might have been formed at the bottom of former oceans, on the very spots, perhaps, in which they are found; and that their figure might have depended more on chemical than mechanical action. But instructed by the paper of Count de Bournon on this subject,[†] I now entertain no doubt of the gravel of Middlesex having been derived from the flints of the upper chalk, and of their having acquired their present forms by attrition.

Whilst speaking of the casts of some of the echini, I stated my doubts of their having belonged to the chalk; but this, I confess, was in consequence of my not being then aware of the various species of fossil echini which the chalk contains. I also concurred in the conjecture, that the calcareous spar of the echinite contained no flint; but I have since ascertained that a considerable portion of silex sometimes permeates the calcareous spar.

[†] Traité complet de la Chaux Carbonatée, &c. par M. le Compte de Bournon.

Fossils of the Chalk with numerous Flints.

Plagiostoma spinosa.	
Inoceramus Cuvieri	in fragments.
Terebratula carnea	Mineral Conchology, Tab. xv. fig. 5 & 6.
. . . . . . semiglobosa	Tab. xv. fig. 9.
. . . . . . subundata	Tab. xv. fig. 7.
Echini	Many of the common species of galeæ, spatangi, and cidares, with some of the cucumerine, clavated, and slender muricated spines.
Sponges	Various species, in a silicified state, sessile, ramose, or umbellate, and some attached to a pedicle. Traces of sponge were also perceptible in the chalk.

In this bed were also found various silicified fossils, allied to sponge, but apparently of a more complex structure. That peculiar asperity of surface, by which the presence of silicified sponges and alcyonia may be detected, was observable in many of the flints of this bed. On the surface of some of these flints, collected by Mr. Phillips, ossiculæ of asteriæ, and of minute encrinites, were observed.

Fossils of the bed of Organic remains with interspersed Flints.

Inocerami	Fragments of different species.
Nautilus	Specific character not distinguishable.
Plagiostoma spinosa.	
Terebratula lacunosa.	
. . . . . . lyra	Mineral Conchology. Tab. cxxxviii. fig. 2.
. . . . . . umbonata	New species. Length one inch; width somewhat less. The larger valve produced one third of its length, the produced part being sulcated, and marked with five alternate small ridges and depressions. The other part of the margin only slightly crenulated, and the rest of the shell plain, except on the upper part of each valve, where there is a circular umbo.
Echini	As in the chalk with numerous flints.

Sponges Alcyonia	These are easily found in this chalk, their texture being rendered visible by a ferruginous tint given to their remains. On immersing in very dilute muriatic acid, such parts of this chalk as exhibit, when fresh broken, a rough and granular appearance, a flocculent membranous substance is separated, of sufficient tenacity to hang from the chalk for the length of one-sixteenth of an inch.

There are various bodies in this bed, which cannot be regarded either as alcyonia or as sponges, but appear to be allied to them.

Fossils of the Chalk with few Flints.

Vertebræ and bony palates of fishes.	
Nautilus	Species large, but not distinguishable.
Ammonite	Species large, but not distinguishable.
Teredo ? annularis	New species. Shell spiral at one extremity, having the spires detached. As it enlarges towards the other extremity it becomes slightly bowed, and ends in a straight subcylindrical tube. Shell thick towards the spiral end, and thin towards the other. At the distance of every quarter of an inch along the shell there are annular risings, the depressions between being smooth, and rising with a circular sweep towards each rising. In its fine spathose substance the shell more resembles a teredo than a serpula.
Plagiostoma spinosa	The shell, in this bed, often retains some of its original colouring.
Pecten	In fragments, too imperfect to allow of distinction.
Inocerami	Same as in the two former beds.

An interesting specimen of an undescribed species of Inoceramus was found in this stratum (Pl. 1. fig. 3.) It is filled by and partly imbedded in flint; sufficient, however, is visible to allow of its being thus characterised.

INOCERAMUS.

GEN. CHAR. A free, unequal-valved, inequilateral, eared bivalve. Hinge, containing an internal ligament and formed of alternate ridges and furrows, across the lower margin of the eared part.

INOCERAMUS Lamarckii.

SPEC. CHAR. The valves roundish, slightly indented longitudinally, and having strong round transverse ribs, with interposed striæ.

Mr. Sowerby having as a tribute of respect distinguished the larger species of this genus as Inoceramus Cuvieri, a grateful consideration of the advantages yielded by the classification of Lamarck has led to the assumption of his name for the designation of the present species.

From the numerous fragments found in this and the other chalk strata, it is evident that many species of this genus existed, differing very much in form and size. Thus in this species the plane of the hinge, nearly agreeing with that of the valves, the shell is nearly equivalved; but in another species the hinge plates are placed at right angles with the valves, the teeth being disposed perpendicularly. Hence in this latter species the larger valve must be involutely curved, to admit of the apposition of the hinge plate of the other, perhaps, smaller and flatter valve. Other specimens show that the hinge plates are disposed in various intermediate oblique directions, in other species of this curious shell.

Terebratula	The species found in the two former beds.
Alcyonium	A botryoidal, enteriform species, and many other bodies allied to this genus.

The chalk of this bed appears to be distinguished by its greater weight and by its gritty feel, which gives the idea of its being blended with minute particles of sand.

Fossils of the Bed of Organic remains without Flints.

Solen ensis ?	Traces of a shell resembling it.

Fossils of the Grey Chalk without Flints.

Nautilus	Length 9, depth 6, width 5 inches: whorls oblique. On the back are small, closely set, transverse, undulating striæ, which agree in their direction with the contour of the shell. Fossils of this description frequently occur in this bed. In a quarry of building stone near to Maidstone, specimens of this fossil are found, which display innumerable variations of this oblique distortion.
?	A large, transversely striated, excentric nautilus.

Not knowing whether the forms of this and of the foregoing specimen proceeded from accident, or, as I suspect, from the original and natural formation of the animals, I have not ventured to give them specific designations.

?	? A hooked multilocular shell, in form like a hamite, marked like a scaphite. Outer border rounded, inner flat. The radii arising from the outer part are terminated by the union of two or three on the middle of the side, which there form a faint tubercle. One extremity is broken; the other becomes smooth, contracts into a groove, and terminates in a mouth resembling that of ammonites bilabiatus. Sowerby, Min. Con. No. 32. The flat inner border seems to render this fossil generically different from the hamites; but this cannot be determined by this imperfect specimen.

Many of the multilocular shells belonging to the chalk, the blue marl and the green sand, such as the nautilus above described, the hamite, &c. are remarkable for the deviations from the symmetry observed in the shells of the same order that are found in the older beds.

Teredo annularis.

Inocerami	Remains of different species.
Terebratula sulcata.	
. . . . . . communis.	
Echini	Cordated and galeated species, more flattened than those in the upper beds.
Alcyonia.	
Sponges.	

In many parts of this bed are perceived small white ramose forms, pervading the chalk, which possibly have been occasioned by some vegetable.

Fossils of the Blue Marle.

A first view of the fossils of the blue marle immediately discovers the remains of animals differing essentially from those of the superior or inferior strata. I have, assisted by Henry Warburton, Esq. compared the fossils of the blue marle from Folkstone with those of the pale marle from West Malling in Kent, and with those of the Gault of Cambridge, being enabled to do so by the specimens in the collection of the Society; from which it appears that in the arrangement of the collection, these fossils have most properly been considered as belonging to the same bed. Indeed there are few fossils found at one of these three places that are not also found at one or the other of the two remaining places. Similar fossils are also found at the foot of the South Downs near to Lewes in Sussex.

Ammonites splendens	Sowerby.
. . . . . auritus	Sowerby.
. . . . . serratus	Flattish, inner volutions much concealed. Strong slightly bowed prominent rays on the inner margin, soon becoming furcated, and passing to the outer margin, where they form two serrated edges, between which lies the siphuncle. Found also at Cambridge.
. . . . . subplanus	Nearly flat, the inner whorls much concealed; rather umbilicated. Curved rays arising in pairs from tubercles on the inner margin pass together with intermediate rays arising from the middle of the whorls to the outer margin, which is tuberculated on each side, and flat between. Found also at Malling, and at Lewes.

Ammonites ornatus	Rounded; the inner whorls displayed. Strong flexuous costæ arising from the inner margin alternate with others from the middle of the whorl, and terminate with those nearly in the middle of the outer margin, close to the siphuncle. Found also at Cambridge.
..... pansus	Rounded; the whorls rapidly encreasing. Sharp ridges, arising furcated from tubercles on the inner side of the whorls, with irregular supplementary ones, pass over the round outer margin, and enclose the siphuncle. Found also at Malling.
..... lautus	Flattish; inside of the whorls set with obliquely dispersed ridges, terminating in tubercles; from each tubercle proceed two or three rays, passing in an elegant sweep to the outer margin, where they unite in pairs and form tubercles, by which the two serrato-tuberculated edges are formed, enclosing the siphuncle. Found also at Cambridge.
	Some other species of ammonite are found at Malling and at Cambridge.
Belemnite	A small species, having an inner tube in the alveolus, being the same as that found at Stutgard. Found also at Cambridge.
Hamites	With plain oblique costæ. Found also at Cambridge.
.... elegans	Not cylindrical, but flattish. Near to each margin is a row of tubercles, which are connected transversely by oblique costæ, dividing as they rise from the tubercle of one margin, and uniting at the tubercle of the opposite margin. Between these are two intermediate costæ, which pass round the whole of the limb, and with two more costæ passing from each tubercle over the inner margin, form upon it a closely crenulated surface. A hamites is also found at Malling, but it seems to belong to a species distinct from the former two.
Pleurotoma ?	Found also at Malling, with several other species.
Teredo ?	Found also at Cambridge.
Inoceramus concentricus.	Cordiform, the upper part of each valve having an extended and twisted neck, so that the beaks are placed obliquely and appear distorted. The surface

	marked with small rounded transverse concentric risings with corresponding grooves. Found also at Malling and at Cambridge. Plate 1, fig. 4.
Inoceramus sulcatus	In the position of its beaks this shell agrees with the last. Its surface is marked with acute longitudinal grooves, commencing below the neck, and gradually enlarging as they approach the base. On the surface of the casts are seen small and close transverse rugæ. Found also at Malling and at Cambridge. The large inoceramus (Inoceramus Cuvieri,) belonging to the chalk, is found in the blue marle at Malling and at Cambridge. Pl. 1, fig. 5.
Pecten	with large rounded costæ.
Nucula similis	Sowerby. Found also at Cambridge and Malling.
. . . . pectinata	Sowerby. Found also at Cambridge and Malling.
Terebratula sulcata	Found also at Cambridge.
Anomia terebratula	Linnæus. Found also at Cambridge.

There are also found at Malling and at Cambridge several species of cancer, an euomphalus, and a conical radiated madrepore. At Malling a cordated echinus; and at Cambridge the pentacrinite, a fossil fish, and wood in thin beds. Wood occurs also plentifully in the marle of Folkstone, lying chiefly at the bottom of the stratum, on the green sand.

VI. *Notes, accompanying a set of Specimens from the Himalay Mountains.*

By JAMES FRASER, Esq.

OF CALCUTTA.

Communicated by Capt. BASIL HALL, R.N.

[Read 20th February, 1818.]

A FEW facts and general remarks regarding the nature and appearance of the country, where the specimens of rock accompanying this communication were gathered, may assist in conveying some faint idea of its geological structure, which the meager quantity and style of the specimens, and the utter ignorance of their collector, are little calculated to effect.

It is well known that the Plains of Hindostan through which the Ganges and its subsidiary streams hold their course, are bounded on the north-east by a mountainous tract, which runs the whole way from the banks of the Burrampooter to the Attock, or chief branch of the Indus, and, crossing that river, spreads out into a less circumscribed and less lofty highland country, the chains of which are connected with many of the chief ridges of Asia, although from our limited knowledge of the geography of those remote districts, their connexion is little understood. Indeed until the late war with Nepal rendered it important to collect information in these quarters, this great range of mountainous country, and the people it is inhabited by, were almost totally unknown to us.

The whole belt of hills which thus separates Hindostan from Thibet, is perfectly connected and unbroken, running in irregular ridges undivided by any valley of consequence from the one plain to the other. The line of commencement on the side of Hindostan is very distinctly marked; the hills rising from a level, which is even lower than the rest of the country, and perfectly free from rock or stone, at once into sharp ridgy and wild hills which are soon lost in the mountains from which they diverge. The other, or north-eastern side of this great belt, if we may trust to the best information that has been obtained, is less sharply defined; the hills fall more gradually into grassy and green heights and undulations, and end in a plain that slopes gently from their summits. If this is the case, it is consistent with the law which was found to hold good in the individual ridges, the more broken and precipitous faces of which always pointed to the south-west and north-west.

Of this mountainous tract, the great Himalay mountains form the central ridge, each succession of hills, however irregular may be the direction of their ranges, rising gradually as they approach this great backbone from which their origin can always be traced; but the loftiest of the mountains not included in the Himalay, so far from nearly reaching their height, appear but as their roots; while the latter highly predominating over all, rear their sharp rocky crests, covered only with eternal snows, to a height almost incredible, in unapproachable, desolate grandeur.

The best observations have fixed the heights of some Peaks of the Himalay at about 26,000 feet above the level of the plains, and these may rise above the sea 500 feet more. Mr. Colebrooke, late President of the Asiatic Society, in a paper to be found in the twelfth vol. of the Asiatic Researches, from a number of observations and various data, lays down the chief peaks of the Himalay mountains at different heights, from 26,862 feet downwards to about 22,000. Jumnotree, whence the river Jumna takes its rise, and which was visited during the tour in which these specimens were collected, is laid down as 25,500 feet above the level of the sea; the route lay over a shoulder of this mountain, which it was conjectured could not be more than three thousand feet lower than its principal peaks.

This stupendous height, exceeding greatly it is believed that of any mountains explored or yet known, cannot but render the range an object of much interest in many points of view; and certainly an accurate knowledge of its structure and the composition of the loftier peaks would be a most desirable acquisition to geological knowledge. Great difficulty must be experienced however in the attainment of this, from the physical obstacles alone that present themselves to the researches of travellers, though these do not form the only ones to be encountered in such a pursuit; in the mean time the most slender approach toward this object may perhaps excite some interest, and be received with indulgence.

The specimens accompanying these notes were collected in that portion of the hilly region which is contained between the rivers Bhagiruttee (or sacred and principal branch of the Ganges) and the Sutlej; the former of which takes its rise in the recesses of the Himalay, the latter has its origin on the north-east face, in Thibet, and in its passage to join the Indus cuts its way through this lofty range.

The general line of the mountainous belt is here nearly from south-east to north-west, the sides of which rise abruptly from the sandy plains, as rocks from the sea. A small ridge rising in height from 500 to 750 feet, and in depth extending from three to six miles, runs next to the plains from Hurdwar (the debouche of the Ganges from the hill) half way to the Sutlej; this consists chiefly of sandstone, of a soft destructible quality, of indurated clay, and sometimes of beds of rounded pebbles and gravel; the face which is exposed to the south-west is the most abrupt and rough; that towards the north-east is more sloping and more covered with wood; seen from a height above them to the north-east, these low hills resemble a wave of the sea that has rolled by, and in some places shews its broken crest half turned back.

The next range of hills in this part of the country is more lofty, running from 1500 to 4 and 5000 feet in height. It is very sharp, rough, and ridgy, cut into deep shaggy dells, and the crests of the ridges are often so sharp that two persons can hardly stand abreast upon them. The rock is of a hard but very quickly destructible substance; it seems to consist of strongly indurated clay, with a great admixture of siliceous matter; its colour a greyish brown; its fracture is generally in straight lines, but preserving no regularity of form, and it soon moulders into dust, of which with vegetable mould the soil chiefly consists.

Just beyond this range rises a mountain entirely of limestone: at the particular point where it fell under our notice, the division was very distinctly marked by the bed of a river, beyond which limestone usurped the place of all other rock. And though I dare not say that this vein runs universally along the range, yet we traced it subsequently far to the eastward, much beyond the termination of the great mountain, having crossed one or two perennial streams, and rather stretching away across the hills in an easterly direction. The chief range of limestone we saw was about 7000 feet high, and exhibited an external appearance quite as different from the range on either side as were its materials from theirs.

A large perennial stream marked the division between this range of limestone and the commencement of schistus. Hitherto the ranges had run in a direction nearly parallel to the course of the great mountainous belt. From this point no such regularity was to be detected. A very lofty peak, 10,500 feet above the plains, reared itself above all others, and from this central point branches of mountains diverged in all directions that were again connected, after many irregular deflections, with the roots of the Himalay ridge, only disturbed by the great ravines, in which run the chief draining streams that intersect the country. These, when they rise in the snowy mountains, invariably commence their course from east-north-east to west-south-west, and then at some stubborn rock turn sharp to the south-east and continue their course to the plains.

The whole of this mass of mountains consists almost invariably of different sorts of schistus with much mica, and plentifully veined with quartz, of which many large rocks and blocks were seen, having little or no other stone among it. There were doubtless exceptions: we saw at times a sandy granulated stone in masses near large ridges, but not of a character that could be mistaken for granite. The beds of the torrents, however, exhibited blocks of granite that had evidently come from a distance, rounded and mutilated by attrition: and there was also a quantity of a blueish-grey stone, of great hardness, brought to its present position also evidently by the force of the torrent, and evincing no doubt of what materials a portion of its early bed consists. But the predominating rock was schist with much mica, in all varieties of colour and hardness. Twice on the top of lofty mountains we discovered sandstone of a coarse gritty nature; and once we were surprised to find the hill face under a very high peak, strewed with gigantic masses of a stone formed apparently of sand, mica, quartz, and small stones or gravel, united by a sort of white spar, which had the appearance at first of great hardness, but in reality was easily broken and very destructible, the whole mountain side being covered with the pulverized and granulated ruins. Ascending the hill subsequently, we found the top composed of chaotic masses of the same rock, from among which the earth seemed to have been washed away, but which still gave root to many luxuriant trees of various sorts.

When we crossed the vein of limestone, the difference between the opposite exposures of the sides of the hills struck us forcibly. Each glen or slope with a southern or south-eastern exposure, was brown and arid in its aspect, the hills were round and lumpy, and though very rough, were yet more sloping than the others, while trees were rare, and vegetables of any sort very scantily spread over the thin rocky soil. The northern and north-western exposures on the contrary were invariably most abrupt, deep, and precipitous; yet their rocky sides were cloathed with rich dark forests of infinite variety; and the lower parts, though often steep, were covered with a rich plentiful mould which afforded the most extensive and the best cultivation; the aspect was always green, rich, and various. The pointing of the naked peaks to the north and north-west, towering above all, was too remarkable to pass unnoticed in any instance. This is a principle which may be traced through every range, to the Snowy hills themselves, which are remarkable instances of the general condition, as will be more particularly dwelt on below.

As we approached the snowy mountains and got among their roots, although schist continued to predominate with its quartzose veins, still exceptions became more frequent; rocks and whole precipices occurred, formed of a very white marble-like stone, which at first we were inclined to believe limestone, or a sort of marble, but we had no means of ascertaining the fact, and were afterwards led to doubt of the existence of calcareous matter in this rock, as we found varieties apparently of the same sort, which were certainly not marble. On the lofty ridges we now traversed, and under the still loftier peaks that overhung us, we frequently lost schist altogether, and found ourselves amid a sort of stone that possessed a semitransparence similar to that of quartz, but which broke perfectly irregularly, was very hard, exhibiting in its fracture a quantity of white shining particles. It was of all colours, grey, blueish grey, red, yellow, and much of a greenish hue. This rock was confined to heights. We lost it the moment we declined into the vallies.

The bed of the river Sutlej, over which the peaks formed of the rock last mentioned rose, exhibited only that various, heterogeneous and undecisive congregation of rocks and stones which usually occupies the bed of a large river which flows with much rapidity through a mountainous country, and swelled by many subsidiary streams that yield their tribute of rocks from their parent mountains, as well as of water. The water of the river was here loaded with a fine white shining sand, that was kept suspended by the turbulence of the stream, rendering it turbid, and giving to it at a distance a hue of a light dirty green: this sand was produced by the attrition of the various light coloured rocks it passed through in its course, and were deposited along its bed; but the native channel here was of schist as usual, and the varieties of colour and consistence were very great.

We penetrated along the glen of the river Sutlej and on the cliffs forming its sides, till we reached the heart of the snowy mountains, the peaks of which rose round us on all sides, and we had here a good opportunity to confirm the observations which we had constantly made while viewing them at a distance. The precipitous faces pointed always to the north and north-west, save when accidental causes broke the face of a hill differently exposed. All the hills, particularly the loftiest peaks which are too precipitous to retain the snow that falls on them, are distinctly stratified, the stone itself seemed lamellar and very sharp, and the strata, according to our best judgment, dipped to the north-east at an angle of about 45 degrees or something less. In those faces of precipitous rock that were turned towards us, the stratification was remarkably distinct, even in the sharpest spires. Our distance from these peaks in a straight line could not be greater than 2 to 2½ miles, and we had good glasses which gave us a very accurate view of their structure, but we had no means of discovering the nature of the rock of which they were composed. From several thousand feet below their tops, all sort of vegetation ceases, not a blade of any thing green can be detected, no living thing can be seen, no soil covers the hard bare and scarred cliffs that spire aloft, battered and shivered by the shock of weather and vicissitudes of seasons; all that is not thus solid rock appears to consist of the moulderings and ruin of these peaks collected in the hollows at their feet.

Such were the snowy hills at Seran, a point within them to which we penetrated, and elevated three miles above the banks of the river Sutlej. On our route, returning to the south-eastward, we held our way for a considerable distance along the bed of a large stream called the river Pabur, which rises far in the north-east among the depths of the Himalay. We found along its banks a quantity of large blocks of a very hard stone, composed of mica, quartz, and a hard grey matter with darker spots, forming a sort of varied grey with a strange striated irregular texture; this was evidently brought here by the violence of the stream, though some of the blocks were of great size: the neighbouring rocks were chiefly schist, some of a good compact quality and tolerably blue, and of quartz in various shapes; much limestone too was found, hard and compact in substance, generally of a grey colour with more or less tendency to blue, and veined with white in laminæ; when the rock was formed of this it sometimes exhibited a red varied appearance externally, but the fracture was of a grey white; it very often lay in strata, dipping more or less, but irregularly, and the direction could not be ascertained; the edges of these strata, frequently projected from the hill side.

Of both these stones, specimens accompany this. We also found some of the semitransparent stone mentioned before as being confined to the heights of lofty peaks. This region of limestone was certainly the continuation of that forming the lofty mountain early spoken of.

At Jumnotree, the source of the river Jumna, another opportunity presented itself of viewing the Himalay peaks with the advantage of close vicinity. Along the banks of that river, in its progress from the lofty mountain where it originates, we observed the same succession of rock as has been detailed above; we detected the vein of limestone thus far to the eastward, and then fell into schist and quartz, till we reached the stupendous Jumnotree, which rises in two grand peaks, deeply covered on the south-east and south with perpetual snow, but pointing a precipitous rocky face towards the north-west. We followed the river, now diminished to a rapid mountain torrent, into the bowels of the mountain whence it arises from a vast number of small rills flowing from the snow, which are collected in a pool at the bottom of a steep slope, so that we reached its very origin, and had proof that the rocks of its channel were the genuine produce of the place, or of its close vicinity; we found here nearly every sort of rock which was observed throughout our tour; two sorts predominated,—that hard grey striated stone first discovered in the bed of the Pabur, very irregular in its fracture, yet here, evidently stratified, and that pure white quartz in large rocks which has been before observed lying in laminæ contrary to the general stratification, which it also experiences; and in several places from between these laminæ trickles a spring of hot water, which certainly contains some extraneous matter, as it incrusts the rocks around it with a hard sandy ferruginous red substance,* of which as well as of the quartzose rock, specimens are given. Micaceous schist, of various colours, red, blue, grey, and white, is found in considerable abundance, with several varieties that I am unable to particularize, but which only exist in rounded small pieces.

The stratification of the rocks forming the banks of the Jumna in this elevated part of its bed, is most particularly evident; the strata are pretty much undisturbed, and seem always to dip to the north-east at an angle of about forty-five degrees; this was taken by the compass as nearly as possible, and it pervaded every sort of rock whatever. The lofty peaks forming the crest of the mountain exhibited the same stratification; and in them it was very clear; the distance being trifling, but enough to blend the smaller parts together.

It is not easy to determine the nature of the rocks forming these peaks, the power of frost and thaw destroys the lower parts, but as there are no glaciers in any part of the snowy hills, it is probable that no partial thaw and subsequent congelation takes place; and that on the summits of these mountains a continual frost lies, preventing the grand operations of this powerful agent combined with the moisture generated by a thaw, in splitting the summits asunder, but below it may act; the avalanches have also great power, and no doubt from these causes the ruins of the loftiest peaks where the mountains are so perpendicular, sometimes find their way below; and judging from such wrecks, and from examinations with a good glass, these peaks are formed of the same rocks as are detailed above in the description of the bed of the Jumna, especially the hard grey striated stone, (supposed by a friend to be gneiss), and quartz in laminæ veining the faces of the precipices, but these exhibit many colours, red, yellow, and grey, and white, probably from accident of weather or ores, for no vegetation of lichens or mosses can take place at such an altitude.

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* Carbonate of lime, coloured by oxide of iron.

From Jumnotree we crossed a lofty shoulder of this mountain, including about thirty miles of country, and descended into the bed of the Ganges, (here called Bhagiruttee) which we traced to its source. For a considerable portion of the road we had micaceous schist: at the loftiest elevation we could not be much more than 3000 feet short of the height of Jumnotree; probably the difference was less. We had passed over much snow, and had experienced much severe fatigue and oppression of the chest from the rarefaction of the air at this great height. One or two of the nearer snowy peaks rose close by us to a considerable height, and from their ruins, the pass below which we were traversing was formed; there was no vegetation whatever, though the time was the 17th of July, and all the lower parts of the hill were rich with verdure. It was a savage scene of desolation and desertness. Here then we had a fair means of judging of the formation of the snowy cliffs. The rocks were apparently similar to those found in the bed of the Jumna; the gneiss predominated much, and there was a good deal of soft micaceous schist, veined with quartz: there were several varieties of a blueish grey stone, I believe whin-stone, some much harder than others; of this and the schist there are specimens. The stratification was here very obvious; the same pointing of the precipitous faces and the same direction and dip of the strata, as before noted. The rocks were of various colours, red, white, yellow, grey, black; and these colours, particularly the white, often ran in strata, but frequently were irregularly diffused. The observations with the glass confirmed our opinion that the summits of the cliffs were composed only of the same rocks as the ruins at our feet.

Our descent to the Bhagiruttee was accompanied by a striking change of scenery, formed by a corresponding one in the nature of the hills. The glen of this river is deeper and darker, and the precipices on either side very far more lofty and terrible than those forming the bed of the Jumna. At this place all appearance of stratification ceased. The rocks took irregular shapes, and spired into lofty and fantastic pinnacles, and this was more remarkable as we approached Gungotree, the holy place near the source, beyond which it is not practicable to go. The rock in like manner was totally different, and this difference of material produced that in the appearance of the mountains. It was here almost universally a hard compact stone, formed of quartoze matter, mica, and a black shining substance, each of these ingredients varying in quantity in different specimens. This stone, I then presumed, to be granite, and have since been informed that I was right. It is found of various hues and appearances, from white to grey, and yellow, with a tinge of red, and much or little spotted with its various ingredients and different tints. For some miles above the point where we descended into the river, micaceous and other schistus still held their place, but for about sixteen miles below Gungotree, nothing was seen but granite.—The lofty mountains above, thinly sprinkled with dark pines, were formed of masses and precipices of this rock, and the river that foamed below had hollowed to itself a trough in the solid stone for its passage. The mountains and peaks surrounding Gungotree are most evidently composed of the same stone; it never affects stratification, but in fracture and formation of every kind is quite irregular and amorphous. It shoots up into crags and spires, the sharpness and boldness of which amaze, but it seems to be entirely the effect of chance, and not at all to arise from any disposition of the rock to form such in particular, for there are many forms of a round and bold nature in another style.

It is not intended to describe this spot, awfully desert as it is, nor to depict the dreadful passes by which we arrived at it, taking leave as it were of this world and entering on one of so novel and hideous, though interesting a nature. This was the extent of our travels into the Himalay mountains, and if I may at all trust to the information I received, Roodroo Himalay, the mountain whence the Bhagiruttee flows, is one of the remotest of the whole, and a very short journey would have carried me through the whole range of snow into the precincts of China. Thus the specimens taken at Gungotree may be considered as fair samples of one of the remotest and loftiest of the Himalay range.

Two days journey below Gungotree, on our return, stratification was again observed, and the rocks gradually returned to the former usual sorts, and so continued without any material change till we regained the plains.

VII. *Observations on the Vallies and Watercourses of Shropshire and of parts of the adjacent Counties.*

By ARTHUR AIKIN, Esq. F.L.S.

MEMBER OF THE GEOLOGICAL SOCIETY, AND SECRETARY TO THE SOCIETY OF ARTS.

[Read May 1, 1818.]

A SPECTATOR standing on the high ground of Weston Point at the head of the estuary of the Mersey (and thus elevated about 300 feet above the sea), if he directs his view to the south, will seem to have before him a wide and nearly flat valley bounded on the right by the hills on the Welch border, and on the left by those of Delamere forest. At the end of the valley will be clearly seen, in usual states of the atmosphere, a group of hills considerably elevated and shutting up the view in that direction. This group, even without the assistance of the map, is easily recognized to be the Breiddin hills situated on the southern bank of the Severn, and marks the point where this river, having hitherto run from its source in a north-north-east direction, begins to flow east, verging more and more to the south, till at length it falls into the Bristol channel.

The distance between Weston point and the Breiddin hills is almost 44 miles, and as this tract separates the waters which run into the estuary of the Dee from those which run into the Bristol channel, it becomes an inquiry of some importance in the physical geography of England to ascertain its absolute height above the level of the sea. Data for determining this point with considerable accuracy are afforded by the levels of the Ellesmere canal, the main line of which extends between Shrewsbury and Chester, and, though not entirely executed, has been completely surveyed.

The summit line which separates the running waters lies nearly east and west. It approaches in one or two instances within a quarter of a mile of the valley of the Dee, and extends with a considerably indented outline from the village of Selatyn a little north-west of Oswestry, to the town of Whitchurch. The high level of the canal passes through this latter town, and after a descent of 128 feet joins the Chester canal, which in its progress to tideway in the Dee at the city of Chester, descends 170 feet 10 inches; making the elevation of the summit line or *water-shed* 298 feet 10 inches above the Dee at Chester. By another line between the two extreme points, surveyed but not executed, the difference of level appears to be only 292 feet; the average of the two gives 295½ feet, which I think may safely be assumed as nearly approaching to the truth.

If from the same summit level we compute the lockage of the canal to its intended junction with the Severn at Bagley brook, near Shrewsbury, we shall find it to amount to a fall of 140 feet. Hence the height of the Severn at Bagley brook is 155½ feet above the tideway in the Dee at Chester.

In order to compare this result with that furnished by levels taken between Shrewsbury and the Bristol channel, I must first state that the height of the basin of the Shrewsbury canal at this latter town above the Severn at Bagley brook, amounts (according to information furnished to me by Mr. Telford) to 24 feet 4 inches. From this basin to the termination of the canal at Coalport on the Severn, the descent on the whole is 59 feet; the canal at Coalport is about 16 feet above the Severn; and the fall of the Severn itself from Coalport to Gloucester where it meets the tide is 89 feet, according to a series of levels taken by direction of the late Mr. W. Reynolds of Ketley. Hence it appears that the bottom of the tide at Gloucester stands on a higher level by about 16 feet than the tide at Chester, which from the form of the Bristol channel and the well known extraordinary height of its tides, added to the greater distance of Gloucester from the sea, is all very consistent with what might have been *a priori* expected.

From the high level of the Ellesmere canal, already mentioned, a branch proceeds to the limeworks of Llanymynech, and is thence continued up the vale of the Severn as far as Newtown in Montgomeryshire. By combining the measurements thus obtained with the preceding ones, a number of interesting particulars concerning the descent of the Severn during the greater part of its course may be obtained, which I shall proceed to mention in some detail, as the rate of descent of navigable and other streams, although a most important branch of natural geography, has hitherto been almost entirely overlooked.

A number of mountain torrents, rising chiefly on the eastern skirt of Plinlimmon, unite at the town of Llanidloes into one main stream called the Severn, which from that place to its entrance into the plain of Shrewsbury flows north-north-east, winding through a a valley a mile or more across. It receives on each hand the contributions of numerous brooks and small rivers, and thus serves as the common drainage into which the superfluous waters of a mountainous tract of considerable extent discharge themselves.

From Llanidloes to Newtown, a distance of at least fifteen miles measured along the bank of the river, are several rapids but no perpendicular fall: the rate of its descent through this space I am unacquainted with. During the remainder however of its course, namely from Newtown to tideway at Gloucester, a distance of between 130 and 140 miles, not only the entire fall, but the descent through particular portions of this space are very correctly ascertained; and, there being neither weir nor lock nor any other artificial obstruction to the free course of the stream from the source of the river to its mouth, the ambiguity arising in other cases from these causes has no place in the present inquiry.

The Severn continues to be a torrent incapable of navigation to Pool-Quay, about twenty miles below Newtown, in which space it descends 220 feet, being at the rate of 11 feet per mile. From Pool-Quay to Bagley brook at Shrewsbury, a distance of twenty-six miles, the entire fall is 96 feet, being at the rate of 3 feet 8 inches per mile. The descent however through this space is by no means equable; for the river, which while in its own valley has banks only a few feet in height, no sooner gets into the alluvial plain of Shrewsbury than it has the appearance of a ditch bounded by steep banks of gravel from 12 to 20 feet deep, the banks themselves at the same time not being sensibly higher than the rest of the marshy district which is thus intersected. Formerly, when these marshes had not been embanked, the greater part of the flood waters extended themselves over this open space, and returning slowly into the bed of the river kept up for many days a depth of water amply sufficient for the purposes of navigation. At present however, now that all these low lands are secured by substantial embankments, a heavy fall of rain of thirty-six hours duration swells this part of the river into a turbulent torrent, rising from 10 to 20 feet perpendicular in as many hours, and declining almost as quickly from its greatest height to its usual shallowness.

From Bagley brook at Shrewsbury to Coalport (about two miles below Coalbrook-dale), the entire distance is about twenty-one miles; the perpendicular descent is 50 feet 8 inches, being at the rate of about 2 feet 5 inches per mile. The greater part of this space is a sandy alluvial tract, terminated by a ridge of limestone, called the Wenlock Edge, the beds of which rising directly opposite to the course of the stream, no doubt contribute in some degree to hold up the water. It is through a breach in this limestone ridge that the Severn escapes out of the plain of Shrewsbury, and at the same time changes its easterly course for one nearly due south, which it retains to its junction with the sea. From Coalport to Bridgenorth, a distance of seven miles, it descends 14 feet 6 inches, being at the rate of almost 2 feet 1 inch per mile. From Bridgenorth to Stourport, the fall is 41 feet 9 inches during a course of eighteen miles, being at the rate of 2 feet 4 inches per mile. In the next thirteen miles, between Stourport and Worcester, a fall of 23 feet takes place, being at the rate of 1 foot 9 inches per mile; and, lastly, from Worcester to tideway at Gloucester, a distance of thirty miles, the fall is only 10 feet, or about 4 inches per mile.

From the autumn of the year 1789 to the end of 1800, a register was kept at Coalport, exhibiting the depth of water in the Severn every day (except Sundays); as however no pains were taken to render the banks of the river at this place perpendicular, it is obvious that equal increments in height imply more than equal increments of water, even not taking into consideration the greater rapidity of the stream in times of flood. I shall however make a few extracts from this document* for the purpose of shewing the quickness with which remarkable changes in the quantity of water discharged take place.

On January 8, 1793, the depth of water was 7 feet; on the 9th it rose to about 17 feet, and on the next day had subsided to 3 feet.

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* See Archdeacon Plymley's Agricultural Survey of Shropshire.

On January 23, 1800, the depth was 5 feet; on the 24th the water had risen to 10 feet; on the 25th to 12 feet; from the 26th to the 29th inclusive, the river had overflowed, and probably was from 18 to 20 feet deep; on the 30th it had fallen to 9 feet; and on the 31st was at 6 feet.

On January 10, 1795, the depth of water being only 2 feet 4 inches, the river was frozen over; it continued in this state till the 9th of February, on which day a rapid thaw began; on the 10th the ice broke up in consequence of the rise of the water; on the 11th the flood was far above all former marks, and continued so till the 15th; on the 16th it was already sunk as low as 5 feet.

On March 10, 1800, the depth was 4 feet; on the 14th, 15th, and 16th, the river had overflowed its banks, and therefore was at least 17 feet deep; and on the 16th it had fallen to 5 feet 6 inches.

On the 4th April, 1792, the depth was 6 feet; on the 5th and 6th the banks were overflowed; and on the 7th the depth of water was reduced to 7 feet 6 inches.

On April 18, 1792, the depth was 3 feet 6 inches; on the 19th and for the two succeeding days the banks were overflowed, and by the 23d the river had fallen again to 3 feet 6 inches.

On May 29, 1792, the depth was 3 feet 4 inches; on the next day the banks were overflowed; and on the following day the water had fallen to $6\frac{1}{3}$ feet.

In the months of June, July, August, and September, no floods occurred during the twelve years that the register was kept.

From October 7th, 1789, to the 9th inclusive, the depth of water was about 6 feet 4 inches; on the 10th it rose to at least 17 feet, continued at the same height during the next day, and on the 12th had already fallen to 7 feet 6 inches.

On the 31st October, 1792, the depth was 5 feet; on the 1st November the banks were overflowed; and by the next day the water had fallen to 7 feet.

In December, the water, generally speaking, stands higher than in the other months, the floods remain longer, and are also longer in subsiding. In those cases where the water has been remarkably low for a week or more successively, the river has at length, notwithstanding its rapidity, been frozen over. Of this phenomenon there are four records in the register before me namely, December 2d, 1796, the depth of water being 1 foot 8 inches; on the 15th of the same month the ice broke, and the water rose to 3 feet; it continued nearly at the same height till the 22d, when the river again froze over, the depth of water being 2 feet 10 inches, and so continued till the 29th.

On the 27th December, 1798, the depth of water being only 2 feet, the river froze over and continued so till January 15th in the next year. Lastly, on the 21st December, 1799, the depth of water being 1 foot 7 inches, the river was frozen over and continued so till January 4th.

The annual quantities of rain in the district from which the Severn derives its water, would be a most desirable and indeed almost necessary element in many important deductions from the facts already mentioned: I believe that no such observations have ever been made in this part of the country. It is well known however, that the mountainous Welsh part of this district suffers considerably in its agricultural produce from frequent and long continued rains; and from a register kept for six years, (from 1796 to 1801 inclusive,) about eight miles south of Shrewsbury, the annual number of days in which rain fell is 191. The entire district may therefore, upon the whole, be called rainy.

From the above mentioned facts it may be concluded that the navigation of a river is very precarious, and liable to long and frequent interruptions, even in a rainy climate, when the descent of the water exceeds 3 feet per mile; and that the highest floods run off in a few hours, even when the descent amounts to but 2 feet 5 inches in the same space.

The highest flat land in the county is Corndon marsh, elevated between 900 and 1000 feet above the sea. From this marsh arises a large brook, which after a southward course of five or six miles, arrives at the village of Moor 730 feet above the sea, and situated in the valley in which Montgomery and Bishopscastle are built, and which forms an oblique connexion between the great Montgomeryshire valley in which the Severn flows, and the valley of the Teme. From Moor the ground slopes so equally both east and west that the very uncommon circumstance here occurs of the stream dividing itself: that portion which goes off to the west, being soon joined by other streams forms the river Camlet, which after an indirect and circuitous course of about seventeen miles, falls into the Severn, above Welsh pool, having descended in this space nearly 300 feet, being at the rate of $17\frac{1}{2}$ feet per mile. The eastern branch after the junction of a few brooks, forms the Onny river and falls into the Teme at Bromfield three miles above Ludlow, having run a course of nearly equal length and fall with the Camlet.

The length of the Teme from its junction with the Onny to its termination in the Severn, about three miles below Worcester, is nearly forty-two miles, in which space it falls 367 feet, being at the rate of about 8 feet 9 inches, per mile: nearly the whole of its course is directly opposite to the rise of the strata over which it flows, which, added to the rapidity of its descent, is obviously the cause of the numerous rapids and rocky ledges, and deep pools by which this river is so remarkably distinguished.

The most rapid part of the course of the Dee is between Corwen and Llangollen, where it falls over ledges of rock, and its channel is contracted by the near approach of the steep banks. The perpendicular fall through the latter six miles of this space, namely from Llandysilio to Pontycysyllte, as estimated from the feeder of the Ellesmere canal, is at least 131 feet, being at the rate of 22 feet per mile, which is by far the steepest descent that I have as yet had an opportunity of measuring. The remainder of its course to tideway at Chester, is about thirty-four miles, during which it falls 174 feet, being at the rate of 5 feet 1 inch per mile. In its natural state it is wholly innavigable, but by means of a weir at Chester, the water is held up so as to allow the passage of small boats for two or three miles.

I shall mention only one more river within this district, namely the Stour. It rises about two or three miles north of Wolverhampton, and after a course of twenty-seven or twenty-eight miles falls into the Severn at Stourport. The entire country through which it flows is coarse sand, sandy gravel, or friable red sandstone. Its source is at least 130 feet lower than the basin of the old canal at Birmingham, and therefore it may be considered as belonging rather to a flat country; its entire fall however is 294 feet, being at the rate of 10½ feet per mile.

If the above facts and the deductions which obviously flow from them are of importance even when relating to a district of comparatively small extent; if they tend, as I think they do very materially, to elucidate the physical geography of a country, and by consequence a very interesting part of geological research, namely, the present diversity in the surface of the earth, and the cause of that diversity, it is manifest that the more these observations are extended, the greater will be the accumulation of facts, and the more assured and general the reasonings founded upon them. There are few parts of England and of the south of Scotland which are not either intersected by canals or in which proposed lines of canal have not been surveyed, or the principal watercourses of which have not been levelled. All these by moderate activity on the part of persons resident on the spot may be obtained from canal offices, civil engineers, and land surveyors. The Geological Society seems to offer itself as the natural repository of these documents, being the only Institution by which they can be arranged, and classified, and applied to use, and in which their real value can be duly appreciated. May I, therefore, be permitted to recommend the subject to the industry and zeal of the members in general, and especially of those whose profession or local situation give to them peculiar facilities of inquiry.

VIII. *On the Form of the Integrant Molecule of Carbonate of Lime.*

By DAVID BREWSTER, LL.D. F.R.S. LOND. & ED.

MEMBER OF THE GEOLOGICAL SOCIETY.

[Read 3d April, 1818.]

FROM the facility with which carbonate of lime yields to mechanical division, its primitive form was determined by Mr. Keir, of Birmingham, and by Assessor Gahn, in Sweden, long before crystallography, in the hands of the Abbé Haüy, had assumed the form and dignity of a science. When this eminent mineralogist found that it refused to be divided in any other direction than by cleavages parallel to the sides of its rhomboidal nucleus, he concluded that the form of its integrant molecule was an obtuse rhomboid. This conclusion was implicitly adopted by mineralogists, till the Count de Bournon announced the discovery of cleavages passing through the long diagonal of its rhomboidal faces, and maintained that the form of its integrant molecule was a triedral prism with inclined bases, or, one half of the primitive rhomboid divided by a section passing through the long diagonals of two of its opposite planes. Count Bournon acknowledges that in many specimens this cleavage was extremely difficult to be obtained; that in others it was impossible to overcome the cohesion of the molecules in the direction of the long diagonal; and that in general the crystals of carbonate of lime which were susceptible of this cleavage, indicated this susceptibility by striæ often very strongly marked and parallel to the great diagonals of two of the opposite rhomboidal faces.*

The Abbé Haüy, in his Tableau Comparatif,† has given the name of supernumerary joints to the cleavages observed by Bournon, and attempts, without success, to discover their nature and origin. In his observations on the simplicity of the laws of crystallisation,‡ he resumes the consideration of them, in reply to the observations of Bournon, but he contents himself with stating some variations in their appearance and distinctness, which lead him to conclude that they are merely accidental.§

In this state of the subject my attention was directed to the phenomena of multiplied images which are exhibited in numerous specimens of carbonate of lime. These coloured images, which had been examined by Dr. Robison, Benjamin Martin, Mr. Brougham, and Malus, were ascribed by all these philosophers to cracks or fissures in the crystal, by means of which the transmitted light was decomposed into the colours of thin plates; but I have demonstrated in two papers on this subject‖ that the tints of these images are the colours of polarised light produced by thin transparent veins of carbonate of lime passing through the long diagonals of the rhomboidal planes. These veins are actual rhomboids of different thicknesses, having their faces placed transversely to those of the rhomboid which they traverse, and adhering firmly to the two surfaces between which they are interposed. Their existence is always indicated by striæ parallel to the long diagonals of the rhomboidal faces. These striæ are indeed the actual edges of the veins, and there can be no doubt that the cleavages observed by Count Bournon are the faces disclosed by separating the vein from the mass which embraces it. In order to determine this point by direct experiment, I took a very transparent piece of carbonate of lime, in which the veins were distinctly seen, and having placed the edge of a knife at the junction of the vein with the mass, I succeeded, by a smart blow, in separating it from the contiguous surface of the rhomboid. In all other places, except at the edges of the vein, the rhomboid resisted every attempt to cleave it. The two disunited faces were as perfectly polished as the finest gems, and surpassed in distinctness any of the common cleavages of the spar.

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* Traité de Mineralogie, tom. II. p. 1, 2, 3, 4, 385, &c. Lond. 1808.

† Paris, 1809, page 126.

‡ Journal des Mines, No. 183.

§ See Bournon's Catalogue, p. 489, &c. Lond. 1813, where he combats with much ingenuity the opinions of Haüy.

‖ Phil. Trans. for 1815, p. 270, and Edinburgh Transactions, Vol. VIII. p. 165.

That one of the two separated surfaces was the surface of a vein, and the other a surface formed by juxta-position to the vein, was not only obvious from direct examination, but was capable of being proved by various optical considerations. The two images, for example, formed by the half of the rhomboid which contained the vein, were actually depolarised by its action, while the two images formed by the other half, had suffered no change in their polarisation. Another proof, equally satisfactory, is derived from the determination of the laws which regulate the action of crystallised surfaces upon light. By these laws I have been enabled to determine the direction and position of the sides and angles upon any surface of a piece of opaque or transparent carbonate of lime, from which all traces of an external crystalline form have been obliterated. In this way the surface of a vein can always be distinguished from the surface contiguous to it, and by the application of this infallible test, I have ascertained that every cleavage of carbonate of lime in the direction of the long diagonal of the rhomboidal faces, arises from the separation of the surface of a vein from the mass which it traverses.

Hence it follows, that the cleavages obtained by Count Bournon exist only in those specimens which are crossed by interrupting veins, and therefore that the triedral prism is not the form of the integrant molecule of carbonate of lime.

In the course of my experiments on the polarising structure of different minerals, I have discovered similar veins in arragonite, quartz, and other crystals, and, in a very perfect manner, in some of the alkaline and metallic salts. The crystallographer should therefore be careful, while he is determining the primitive form of these or other substances, that he distinguishes the real cleavages of the *homogeneous crystal* from those faces which may be presented to him in cases of irregular crystallisation.

IX. *Descriptions of some new Fossil Encrini and Pentacrini, lately discovered in the neighbourhood of Bristol.*

BY GEORGE CUMBERLAND, ESQ.

HONORARY MEMBER OF THE GEOLOGICAL SOCIETY.

[Read 17th April, 1818.]

THE fossils represented in the accompanying drawings are so beautiful in their forms, and add so much to the history of the encrini, inasmuch as the greater part of them are of new species, that I have thought the figures of them would prove interesting to the Geological Society. The principal part of them has been discovered in the limestone beds on the river Avon near to Bristol, which pass from thence in a direction a little to the south of west to the sea at Clevedon point, at which latter place remains of this class are abundant. One of the beds near Clifton, called the black rock, contains parts of stems of encrini in great quantity, and sometimes white circular rings of calcareous spar. It was, I believe, first suspected by Mr. Brackenridge and Mr. Miller, of Bristol, that these latter were the hollow heads of the same animals. On polishing several specimens cut in different directions, there appeared no reason to doubt the correctness of this supposition, although the compactness of the stone rendered it impossible to extricate them.

A polished specimen of the limestone of the Black Rock containing one of. these supposed heads, is represented in plate 2, fig. 1.

After much research, Mr. Benton found in a crevice in these beds a specimen of one of these heads, which is now in Mr. Miller's collection. This discovery proved the truth of the supposition, as it was evidently the section of a similar body which caused the marks before mentioned in the limestone. In these crevices, clay was found in which were many detached plates of the upper parts of encrini, apparently of different species, as well as portions of stems or trochitæ, as they are usually called; among the latter were several of different species both cylindrical and pentagonal. Since that time, many gentlemen of this vicinity have sought with much activity for similar objects. Their activity has been rewarded with considerable success, as the accompanying drawings will shew. I will now proceed to describe these objects, noticing the spot where each specimen was found.

Plate 2, Fig. 2.

This specimen was discovered by me in the month of August, 1816, in a shelf of decomposing limestone, near Woodspring Abbey Farm, in the neigbourhood of Whorle in Somersetshire. It is to be regretted that these bodies are generally much broken and injured, and it is very rarely that one is found as perfect as the present specimen. Its plates are of a lightish colour, and the limestone that fills it is much harder than that in which it was imbedded.

Plate 2, Fig. 3.

Is another of the same species, from the same limestone at Woodspring. This species has probably some resemblance in its nature to that in the British Museum, which has been called by Mr. Parkinson, the Nave Encrinus (see Organic Remains, vol. 2, pl. 17 fig. 3,) as in this specimen are seen the double openings for the branching arms.

Plate 2, *Fig.* 4.

In November, 1816, Mr. Page discovered the specimen which is here represented in a fragment of coarse reddish limestone, containing many remains of encrini, at Burrington Combe, twelve miles from Bristol. The specimen is much weather-worn, but appears to have a considerable resemblance to the nave encrinus before noticed. The drawing is of the natural size.

Plate 2, *Fig.* 5 *and* 6

Is a fragment exhibiting the interior of one of the same species as the preceding, and from the same place; it was with much difficulty cleared from the limestone in which it was imbedded. A magnified representation of the arrangement of the plates is given, fig. 6. These hexagonal marks are darker than the rest of the specimen.

Plate 2, *Fig.* 7

Is another head, found also by Mr. Page, at the same place. It is particularly interesting, as shewing one of the passages into the branching arms which is perfectly smooth, as well as the whole of the cavity. There is also a small passage entering the stem, which is not visible in the drawing. This specimen differs from the preceding, in wanting the dark hexagonal figures. The size of the drawing is that of the specimen.

Plate 2, Fig. 8.

Found at Burrington Combe, in 1817. This drawing is a little larger than the specimen, which is filled with white calcareous spar. The specimen first found, as mentioned page 88, was nearly allied to this, though not of the same species.

Plate 3, Fig. 1.

This fine encrinus was found by Mr. W. Morgan, in Clevedon Bay, near Walton Castle, Somersetshire, in the autumn of 1817. It is, I believe, of an entirely new species, and shews both the stem and the branching arms in connexion, the arms being nearly closed together. The lower edges of the first plates are crenated in a manner different from any I have hitherto seen.

It was discovered in one of the sandy beds that alternate with the limestone at Clevedon Bay, and when first discovered, only three or four joints of the stem were visible, the rest being concealed by the sandstone. By care and perseverance it has been cleared to the extent represented in the drawing, which is a very little larger than the specimen.

Plate 3, Fig. 2.

This remarkably large specimen was found by Mr. John Morgan, partially exposed and attached to the underside of a bed in the sandstone. Considerable difficulty occurred in obtaining it, as we were obliged to break away more than a ton weight of stone before it could be safely removed from the rock. Parts of stems of this species are common in this rock, but it is the first instance I am aware of in which the upper part has been found; it is therefore highly interesting, as adding to the history of this species.

Plate 4, *Fig.* 1 *and* 2.

These two figures represent the two sides of a specimen found by me in September, 1816, near to Clevedon; and in order to make out its detail with accuracy, I have made the drawings somewhat larger than the size of the original. It was found nearly buried in a mass of very hard limestone of a grey colour.

Plate 4, *Fig.* 3

Is a considerable fragment of another species, a little larger than the original, which I have cleared as well as I could from a silicified stone rolled on the beach. It is interesting, as having the stem.

Plate 4, *Fig.* 4 *and* 5.

This specimen exhibits the upper joints of the stem of a pentacrinus, and the commencement of two of what appear to be the arms. It was found in a wall at Shipham, near Axbridge, in Somersetshire, by Mr. Morgan. Fig. 5 shews the natural size.

Plate 4, *Fig.* 6 *and* 7.

This specimen was found in a magnesian sandstone in Clevedon Bay, by Mr. W. Morgan, in August, 1816. Fig. 7 represents the natural size.

Plate 4, *Fig.* 8, 9, 10, *and* 11.

This beautiful specimen was found at the same time and place as the preceding, only a very small part of it being visible. Having by much care and labour succeeded in developing it, I immediately made the accompanying drawing. The specimen had so much symmetry and was so beautifully perfect in all its parts, as to appear artificially carved. Unfortunately Mr. Morgan has since injured it by immersing it in dilute muriatic acid. Fig. 8 is a side view; Fig. 9 the upper part; Fig. 10 the lower, where the stem, if it had one, must have been attached. Fig. 11 the natural size. None of the joints of the arms are to be seen in this specimen, but one which I have in my own collection, and which I believe to be of the same species, exhibits part of three arms which ramify in the manner usual with pentacrini. This specimen is however too much weather-worn to be engraved.

Plate 4, *Fig.* 12

Represents a specimen on which are portions of the upper parts of two pentacrini of a scarce species, one of them having a part of the stem. This was also found in the magnesian sandstone at Clevedon Bay.

Plate 5, *Fig.* 1.

This singular specimen, which I consider to be a species of encrinus, was found by Mr. W. Morgan in August, 1816, in one of the upper strata of inclined gritty limestone, forming the east end of the ridge of rocks in Woodspring bay, near Whorle, in the Bristol Channel. Many fragments and single plates were found at the same time, but no other specimen that shewed the general form. On examining this figure it will be observed that there are three lines in which the plates are set in a regular vertical order on each other, and diminishing in size as they ascend. The other plates are differently arranged in respect to each other, and fill up the intermediate spaces, the number of the intermediate plates in each row increasing as they ascend. This figure exhibits about half of the cup-like form of the animal, and it appears that there must be two more lines of the vertically-arranged plates in the concealed portion. The edges of the plates are deeply serrated. The figure is about twice the natural size.

Plate 5, *Fig.* 2, *and* 3

Are two views of a specimen in my collection which is allied to the preceding, and was found in the upper part of the same rock, near the soil. It is somewhat decomposed, but is curious from the different sizes of the plates on the two sides.

Plate 5, *Fig.* 4, 5, 6, *and* 7.

This is the part of a pentacrinus, which is situated immediately above the columnar stem; its size is that of a common pea; and from fig. 4 it will be seen that the stem must be unusually large in proportion. It was taken from an ochreous limestone in a state of decomposition, at Stinchcombe, in Gloucestershire, by Mr. Shrapnell of Berkeley.

Plate 5, *Fig.* 8, 9, *and* 10.

Figure 8 represents a plate of an encrinus, of which several have been collected from the weather-worn sides of the black rock at Clifton, and they are often found in the clays that fill up the crevices of its strata; but hitherto no specimen has been found in this neighbourhood in a more perfect state. In the British Museum there is one which has several plates connected together in their places, and forming the lower part of the body, whence the arms spring. The two following figures, No. 9 and 10, are from the Ashmole collection at Oxford; Professor Buckland having allowed me to take drawings of them for the better illustration of this subject. Fig. 9, is a plate resembling those found at Clifton, but having the first joint of the arm attached to it. Fig. 10 is from a more perfect specimen. The locality of these is not known.

Plate 5, *Fig.* 11.

This specimen is from the magnesian limestone at Clevedon, and is remarkable for the appendages which arise from different parts of the stem. These are different in the order of their insertion from those which are seen in the recent pentacrinus, the latter being in regular verticillations. The manner of their insertion is also different, as they appear to be connected with more than one joint of the stem. In our present state of ignorance as to the nature of these bodies, it is desirable to collect all the materials we can, in the hope of being at length able to explain the use and nature of the various parts. At present I am unable to offer any conjecture respecting these side arms.

Plate 5, *Fig.* 12

Is another specimen from the same rock, consisting of several portions of stems variously bent. These occur very frequently, but we have not, as yet, satisfactorily ascertained to what species they belong.

Plate 5, *Fig.* 13.

I believe this to be the lower part, or attachment of the fine species, represented plate 3, fig. 1, near to which it was found.

XI. *On the Limestone Beds on the River Avon, near Bristol; with a description of the Magnesian Beds that repose on their basset edges.*

BY GEORGE CUMBERLAND, ESQ.

HONORARY MEMBER OF THE GEOLOGICAL SOCIETY.

[Read May 1, 1818.]

THE Society having been pleased to publish in the 4th* volume of their Transactions, the early part of my catalogue of the thirty-two beds of the Limestone series on the Avon, beginning from the Hotwells, and lying above the coal No. 5, I have now completed the measurement of the whole connected range, from its junction with the sandstone to its termination at a place called Cook's folly, always accompanying the towing-path of the river Avon, and marking the mighty fissure in which that river flows.

This new series consists of above 300 more beds. It will be seen that in a few instances I have been obliged to resort to computation as to thickness, because there are certain spots inaccessible, owing to partial coverings of the soil, but I have been careful not to omit notices of any intervening depositions between the beds, marking as far as I was able the organic substances they contain.

We now proceed from my No. 32 of the first series already published, page 197 of the 4th volume of the Geological Transactions.

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* Geological Transactions, Vol. IV. p. 197.

No.		Ft.	In.
33.	Grey and red marles without rubble	12	
34.	A bed of iron stone divided by cracks	16	
35.	Clay ironstone dividing it		1
36.	Marle like No. 33	12	
37.	Ironstone, a bed (by Mr. Powell's account)	12	
38.	Bed of limestone, reddish	15	
	This is the heavy mass that separates the little garden of Mr. Jugland on the zig-zag walk up the hill from the large house at the end of the small crescent; belonging to this face is the		
*38.	White, marley powder.		
39.	Second bed of coal, behind a house, No. 6, Hotwell-crescent, now covered by buildings		3
40.	Rubble bed in Mr. Jugland's garden	6	
41.	Limestone, mixed	5	
42.	Rubble	3	
43.	Limestone, grey and red	4	
44.	Horizontal or curved laminæ.		
45.	Marle, yellow and red and blue, a little schistose and free from stones	4	
46.	Rubbly, red, schistose, marley, and lying conformable in a stripe	3	6
47.	Limestone bed, grey, free from shells	10	
	Here we leave the garden and get on to the zig-zag walk.		
48.	Rubbly bed not easily seen about	9	
49.	Bed of compact grey limestone	4	
50.	Ditto only separated by a crack	3	
51.	Five more beds of limestone (grey) by computation	12	
52.	A bed of ditto with anomia productus, of a large size, and coral subdivided by cracks	10	
53.	Bed of limestone ditto grey	10	
54.	A great bed which I could not get at to measure or take specimens from, as the bathing sheds cover its base, and above it is inaccessible, but I take it to be at least 21 feet,		

No.		Ft.	In.
	much fractured crossways, and much subdivided but not regularly; under this probably the hot springs rise	21	
55.	Limestone bed	2	6
	Separated by three rugged beds, viz.		
56.	Limestone fractured		5
57.	Ditto rotten and parted		8
58.	Ditto more solid		5
59.	Limestone bed regular	2	
60.	Ditto	2	
61.	Ditto	2	
	Separation only red loam.		
62.	Ditto cracked and fractured both long and crossways	9	
63.	Separation red schistose limestone with corals		5
64.	Limestone bed with anomia, productus small	4	
*64.	Separation red marle inclining to schistose, in which I found the euphorbium, a good specimen	1	
65.	Limestone bed of a reddish tinge, the upper part of a schistose texture where most exposed	3	
66.	Its upper part decomposing		3½
67.	Bed of the same but upper part not so much gone	2	2
	A crack with spar and coaly schistose vein		1½
68.	Limestone bed, small anomia	5	
	Second series of limestone commencing at the foot of the bold head that terminates the first series from Powell's gardens, just beyond the Hot-well house, including a space of 150 of my paces.		
69.	A bed of grey limestone in four divisions, nothing intervening	8	
70.	Rubble and argillaceous marle highly schistose, one inch of which is pure ochreous marle, and two inches of dark compact ditto, in all		3
71.	Limestone bed		3
*71.	A limestone bed with shells, red schistose		2½
72.	Ditto, narrowing as it ascends to the horizon	1	8
	on a bed of brown schistose marle		2

No.		Ft.	In.
73.	Rotten bed with shells		11
	bedded on brown clay as above		2
74.	Limestone bed, same as above with large productus		9
	beneath brown marle		1
75.	Limestone bed	1	3
	on coaly schist		1
76.	Limestone, same	1	6
	on division of red marle		¼
77.	Limestone bed	2	
	under of yellow marle		2
	Pipe-clay		1
78.	Red schist		5
79.	Compact bed of grey limestone without shells or other bodies divided by a crack only	3	
80.	A waving vein of dark red limestone, upper part almost shale, bottom hard and red		8
81.	Dark grey limestone with small veins of spar; no organic remains	2	4
82.	A light grey limestone, very compact; no organic remains	1	6
83.	Ditto	1	1
	separation of shale		1½
84.	Same limestone, very close and compact at the top of the bed	3	6
85.	Limestone bed, having small anomia occurring in the middle		10
86.	Ditto with shells		6
87.	Ditto		5
88.	Ditto all same rock, no division, but the natural cracks all veined crossways in lines or white streaks of calcareous spar	2	
89.	Knarly bed shattery, partly solid blocks irregularly cracked and bent, interspersed with thin solid veins of from one to two inches in thickness, of a coaly colour, efflorescing on exposure to the air, two feet irregular, then one foot shattery and slaty	3	4
90.	Limestone, regular amorphous fracture		4
	Separation beneath of coaly shale		3

No.		Ft.	In.
91.	Limestone bed, compact, inclining to pale brown	1	
92.	Ditto	1	2
93.	Ditto	1	
94.	Ditto	2	
95.	Ditto	3	
	Then very thin shale division		$\frac{1}{2}$
96.	Ditto	8	
	Then division		$\frac{1}{4}$
97.	Limestone bed dark, compact, with some few anomia	2	
98.	All irregular in masses of limestone similar to the above, cavernous and cross veined	15	
	A division		
99.	A regular stripe of hard limestone, with anomia in abundance		4
	Red marely schist		$\frac{1}{4}$
	Limestone bed without shells		2
	Red marely schist		$\frac{1}{4}$
	All in a regular sweep downwards.		
100.	55 feet of irregular bending strata divided only by cracks, making about 15 or 16 beds of limestone.	55	
	All agreeing with No. 100.		
101.	Regular strata, with shells of anomia, in part compact and darker	4	6
102.	Ditto	7	
103.	Ditto	4	
104.	We now come to beds of grey limestone exposing their broad flat basset edges dipping exactly to the S.S.E. in an angle of 26 degrees, which is nearly the inclination of all the series	12	
105.	Second broad flat ditto	12	
	The beds here diminish a little in thickness, as they ascend from the river, both have a few shells and common anomia.		
	River still north and south, but here half a point to the north.		
106.	Here a narrow cross vein of calcareous spar 6 inches wide cuts off the beds in a perpendicular direction—it is not quite filled up, and is discoloured by ochreous rust.		

No.		Ft.	In.
107.	Limestone ditto, but disturbed by fractures every way—the rock, which has not ever been worked, ascending rapidly.	16	
108.	Same as No. 107	20	
	Then follows an irregular bank of		
109.	Limestone spreading out like a buttress	30	
110.	Ditto	6	
111.	Ditto	3	
112.	Ditto	8	
113.	Ditto	2	6
114.	Ditto	8	
	Here another vein of spar, No. 106, cuts off the strata perpendicularly, and 36 feet further from the bound stone marked B. 12. is the end of this third series of beds, where a warm spring, exactly similar to the well spring, issues out 15 feet from the towing-path; but this spring is very small, and flows only during the winter months, from December to March, or April, shrinking with dry weather, and rising with rains.		
115.	Limestone bed	4	
116.	Ditto	2	
117.	Ditto	8	
	A bold angle containing 6 feet of the upper part of a new stratum terminates the highest part of this lofty series,—and here a new series begins, the first bed of which is difficult to find, but all are of the same grey good limestone, and the first at 20 paces beyond the angle northerly is	6	
118.	Limestone	6	
119.	Ditto, with veins of schist resting on the great broad and long face that abuts on the old lime-kiln—it is a surface of 100 feet upwards and 50 feet across, and dips not as the others do S.S.E. but nearly north and south.	10	

This extensive and elevated quarry seems to have been abandoned on account of the faults in its beds, and its being underlaid in a contrary direction to its dip, by the vast and compact bed of limestone that slopes from it in an angle of about 15 degrees towards the river, and unequally towards the south-west. A mass I believe without joints and impenetrable. It has shells, and is in part oolitic, and of a lighter tint than the great beds resting on it, some of which are also oolitic, and decomposing in parts. I traced the circle of this quarry and found all within reach good grey limestone, with a few anomia only. This point at the lime kiln, like the last described, exhibits a fragment of another bed of some magnitude, and irregular in its construction; in fact it is the underpinning of the whole mass, and seems to belong to the *front of another series* whose other beds have sunk out of sight, for from this spot to a bank beyond the *capstern* placed to assist in warping the shipping coming into port, (being 52 paces,) we find only a gap filled with rubble from the scar, and very red marle, forming a narrow valley, in which are cold springs that often flow profusely into and weaken the bank of the river that here is divested of its rocky boundary.

The curve this working has made from the river towing-path is very considerable, and above it overhangs the hole, called St. Vincent's cave, which once was accessible, but has been lately rendered inaccessible by blowing away the narrow shelf that led to its entrance.

We are still at the termination of the fourth inclining mass of rocks, each highest at the northern end, forming deeply serrated edges towards the north side of the river Avon, and whose summits form an inclining plain, bearing to the south of south-east, on which part the noble village of Clifton is built; and here we may be allowed to digress, following up the rubble valley where the capstern is, till we come on the plain at Clifton turnpike, in order to point out a very extensive filling up, perfectly horizontal, of magnesian sandy limestone, with a thick under bed of breccia, conformable, containing siliceous fragments, as well as calcareous ones, both bouldered and fractured, with cavities containing spar of both sorts.

The first symptoms we discovered of it are 100 feet north of the road, where a single stone crops out, worn round.

Here follow its Beds.

1. Sandy magnesian limestone.
2. Another bed larger and angular.
3. Another cropping beyond.
4. Another cropping at 400 feet from the gate, which first indicates its horizontal position.
5. A subsidence of the hill, and a long section, the first step of the flat in which I first found an angular large piece of grey limestone imbedded in the heart of the mass, of which
6. Is a specimen of that limestone.
7. Another from a square block slipped forward on the green sward shelf and resting on the aggregate.
8. Another more forward.
9. From a vein of limestone penetrating a fissure in the magnesian bed, having stems of encrini.
10. From a bed of coarse breccia under the magnesian bed 15 feet high, and extending the whole of its length, with great pieces of limestone, organic, oolitic, and plain,—masses of magnesian limestone, quartzose sandstone, soft sandstone,—and all these both rounded and angular. The cement ochreous.
11. Is from a great bed of limestone, whose basset edges crop under the magnesian about 10 feet thick.

*11. From its base with organic bodies.

12. From the upper surface.
13. From a ferruginous limestone bed highly impregnated with iron, that cuts off these beds and dips conformably with them, and is cavernous, and laminated, having 20 stripes in its whole thickness of one yard.
14. The upper lamina involving quartz pebbles very small—this stripe of dark red limestone decomposing, I find again at the river side north of the capstern.

We now descend and return to No. 120 on the towing-path, where the grassy valley full of rubble and red ground embraces a space equal to 90 paces, from the lower part of which a small spring issues, as before mentioned, near the capstern on the bank at No. 11, *C. B. Bound mark*: proceeding 41 paces from this bound-stone we find a small rising bank, a head consisting of ironstone decomposing into a marly shale, brought down from No. 11, 12, and 13 (the beds last marked) of a violet red colour, and like all the other beds before noted, in its dip covered by deeply rufous earth.

		Feet
121.	A solid bed of grey limestone	6
122.	Under it a ferruginous compact *breccia* without division, the limestone and iron as it were melted into each other, and very tough, uniting into a ferruginous limestone .	7
	The whole an irregular head of 20 paces long, and forming in a sort of twisted small arch upwards dipping suddenly northerly, so as to exhibit a sort of hollow way of about 12 paces broad, into which lay bending downwards several very narrow stripes of	
123.	Hornstone, schistous-looking limestone in a stripe of two inches each, capped by grey marle and red earth, and similar stripes of magnesian limestone, and highly ferruginous limestone.	
124.	A second irregular mass of 20 paces long, capped by a honeycombed-trap-looking bed: over which is red earth.	

No.		Ft.
125.	A third mass of limestone 44 paces long, first rubbly, then a mass of limestone that has encrinital remains.	
126.	Full of small stems of encrinus, &c.	5
127.	Smaller beds alternating with red earth for 50 paces, without organization, and grey the least of them.	
128.	A darker grey limestone, and more full of organic remains.	
	☞ Here on looking up we see the magnesian limestone like a wall, overhanging at the horizon the abutting edges of these inclining strata. Leaving these beds which extend from the Capstern point, is a division of 20 paces of rubbly ground, through which appear small irregular patches of grey limestone, the soil all deep red, and they lie sweeping to the horizon, on one point horizontal; in all including a space of 140 paces to the next great *iron ring and mooring chain.* These broken beds of 16 feet in all, lying in deep red marle, with divisions of beds of coralloids, decomposed and ferruginous, some of red and some of grey limestone.	
	You see them next broken by a vein of	
129.	Ironstone, 13 paces from the *ring and chain*, and one foot thick, which dips perpendicularly almost to the River. Next are three limestone beds, each parted by a little red earth *and veins* of decayed coralloids between some of them	3
130.	Another limestone bed cracked both ways, of a red earthy colour, beginning from the *chain and ring* mentioned above	8
131.	A broken bed separated by marle and rubble . . .	3
132.	The rubble limestone, cap of a bed	10
133.	A mass of cross-fractured limestone, red oolite, within nine paces of a bound stone marked *(N. 10. C.B.)* . .	6
	From this boundary stone we follow on the towing path 51 paces without any thing offering but red earth; then we come to a conformably inclined thin bed of yellow marle.	
134.	A limestone bed grey	12
	Separation red marley soil	3

No.		Ft.	In.
135.	Limestone bed solid	1	
	Separation, rubble and broken bed	3	
136.	Limestone split in three parts	2	
	Vein of grey marle, and rolls of grey limestone, inserted loosely	3	
137.	Limestone	6	
	Separation red earth	3	
138.	Limestone	3	
	Separation red earth	1	
139.	Limestone	2	
	Separation red earth		4
140	Limestone	1	
	Separation shaley		6
141.	Limestone	3	6
142.	At this place commences a bold rising head very rugged, and almost hanging over the towing-path, which rises over a mass of limestone that enters the bed of the river forming a precipice; this and the three last beds belong to an irregular winding bed of grey limestone beyond, whose whole surface is deeply tinged with a ferruginous coating; measuring by computation, for I could not get safely at it	35	
143.	Under which is a regular bed of	15	
144.	And another of	18	
145.	Then another of	6	
146.	Another with encrinital remains, shells and plates of echini	8	
147.	One of	3	
148.	One of	5	
149.	One of	15	

All these beds are coated with the dark ferruginous crust—all grey limestone, have been formerly worked—and are separated only by cracks without any intervening body, and end at the boundary stone *No.* 9, *C. B.* where they form a winding head of some magnitude, that terminates as it were this *fourth series* by a valley as usual forming another serrated edge of this chain; and these

No. Ft. In.

are the beds whose basset edges are covered by the magnesian limestone in horizontal strata, before noticed; some small fragments of which may be observed from the spot overlapping the highest bed in view in a thin lamina. Fragments also may be found below, that have fallen in parts.

From the boundary stone (*N.* 9. *C. B.*) to another (*BDC.* 1810) 30 paces further on, we may reckon a few broken off beds, underpinning and supporting those above mentioned, as belonging to this series; after which we commence again where we left off, at the greatest quarry that is now working actively; *these beds are*

No.		Ft.	In.
150.	Bed of red limestone	15	
151.	Two others	15	

that are covered by rubble, stones, and grass, forming a little mound. Then other small beds, under another swelling mound, covered with rubble and turf.

No.			Ft.	In.
152.	The first one a compact red - - - - -		1	6
153.	Second - - - - - -	All grey splintery.	3	
154.	Third - - - - - -		3	6
155.	Fourth - - - - - -			6
156.	Fifth - - - - - -		3	
157.	Sixth - - - - - -		3	6
158.	Seventh - - - - - -		3	

Here begins the Great Quarry at boundary stone (*B. D. C.* 1810.) which ends with the same marked boundary stone, measuring between them 480 paces from working to working, and we shall consider it as the

Fifth Series. This *Great Quarry*, now working,

159. Commences with a bulky head of grey limestone, containing very rarely the large anomia, but no other shells or encrinital remains. The further end has some beds of coralloids, that are very abundant and very much expanded. This bulky head dips at the usual angle, and is the lower-

No.		Ft.
	most of seven thick beds, capped by many thin beds, whose seams and coating are ochreous and yellow at the upper part, where is a small filling up of a sort of magnesian marle, in which hundreds of perfect calcareous crystals lie loosely imbedded, from the size of the tenth of an inch to half an inch. This elevation of beds I take by computation to be above 100 feet; it is cut off by a slip coated thinly by spar, as most of our slips are	100
	Next are,	
160 161 162	Three great beds of 12 feet each	36
163 164	Two more subdivided	
165	One of	4
166 167	Two of seven	14
168	A mass being a perpendicular wall	20
	Under which appears another slip facing the south with a surface: next are,	
169 to 174	Six beds—coated by a thin regular bed	8
175 to 178	Another followed by three other smaller	9
	Another slip of 20 feet	
179 180	Two more beds 12 feet each	24
181 to 186	One bed 9 feet; one 7 feet; one 9 feet; one 4; one 3 feet; one 6 feet	38
187 to 190	One 4 feet; one 3 feet; one 6 feet; one 5 feet	18
191 to 196	Six small beds, one and a half foot each	9

And here ends the Great Quarry at the second boundary *(B.D.C.* 1810.*)*

No.		Ft.	In.
197.	A bed protruding from a bank of grey compact limestone	6	
198.	Ditto, nearly united	6	
	Separated by 22 pieces of sloping rubble bank covering beds from		
199.	A limestone bed	3	
	Separated by 32 paces of sloping rubble bank, then		
200.	A bed shattery at bottom	1	6
201.	Ditto, solid	2	
to			
206.	Six very thin beds, unequal	6	
	Separated by 34 paces of sloping rubble bank.		
207.	A bed of grey compact limestone, splintery	1	8
208.	Ditto, connected	2	3
	Separated by red marley earth one yard, irregular.		
209.	Buttress beds from hence to *the houses*,* and behind them, say	12	
	This the buttress end of 5TH SERIES.		
	SIXTH SERIES, beginning just beyond the white houses of the new Hot Well, where there is a wall to the river, and a fine spring of *warm water* flowing into the river.		
210.	A bed of blue fine compact conchoidal *limestone*	1	
211.	A bed of blue fine compact conchoidal	1	5
	Separation black shale.		
212.	A bed of blue fine compact conchoidal		7
213.	A bed of blue compact, shaley under		7
214.	Ditto, ditto		4
	Separation five feet of brown soil.		
215.	Rotten strata	1	
216.	Blue fine compact	1	3
217.	Grey compact	1	5
218.	Blue compact	2	

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* The houses I allude to are four or five cottages on the near side, with a wharf-wall at this part of the towing-path, where the cottagers sell specimens of spar, &c.

No.		Ft.	In.
	Separation of two yards of marley soil.		
219.	Blue compact conchoidal	1	3
220.	Ditto	1	8
221.	Ditto, very compact	2	
222.	Bed of grey splintery	3	
223.	Grey compact	1	
224.	Ditto	1	7
	Separation brown soil of five feet.		
225.	A bed of blue compact		6
226.	A regular bed of very shaley matter of various colours, yellow, blue, and black	1	6
227.	A bed that is fast proceeding towards a state of rotten-stone, most solid in the center and towards the bottom, in no part shaley. It should seem to have offered originally some impediment to the matter that has saturated the other beds, yet we cannot see any organization through the whole. What we now call marley beds, were probably such beds entirely decomposed . . .	4	
228.	Loose beds	4	
229.	A thin bed compact, shattery, irregular fracture . .		6
230.	Ditto		2
231.	Ditto, quite compact, blue . . . . . , . . .		4
232.	Ditto, grey, splintery, coarse	1	10
233.	Under is a separation of six inches of yellow marle, that has undoubtedly been a bed.		
234.	A bed as N°. 232		8
235.	Ditto		6
236.	A bed of blue, fine, compact	2	
	Separation, thin broken beds of limestone as above, projecting from earthy banks under grass, one of which has a schistose fracture; viz.		
237.	A specimen		3
	The whole occupying about 26 paces.		

Then we arrive at a small projecting point rising from under these, where is a remarkable vein of bright yellow

No.		Ft.	In.
	decomposed limestone, which the miners use for stopping up the grooves made to blow the rock, being purely calcareous.		
238.	Bed	2	
239.	Compact blue	1	
240.	Compact blue resting on	1	
241.	Schistose marle		4
242.	Rubble bed of ditto		5
243.	Yellow stopping earth, decomposed limestone	2	3
244.	Brown earthy limestone	1	
245.	Broken specimens of blue limestone		8
246.	A bed of limestone much cracked across	1	4
247.	Yellow stopping, fine, earthy limestone		9
	An irregular vein.		
248.	Broken beds of schistose limestone	3	6
249.	Ditto	2	6
250.	Broken and separated, all similar to N°. 245	4	
	Here commences a noble set of beds of fine pure oolite, without any organized bodies; fracture splintery, conchoidal, sometimes the best in all our rocks for burning. Stained from light rufous to light grey.		
251.	A thin bed of oolite	2	6
252.	A great bed of ditto, with fractures innumerable, in a perpendicular direction, computed at	32	
253.	A ditto of ditto, scarce any division	15	
254.	A ditto of ditto	10	
255.	A bed of oolite winding	8	
256.	A ditto	2	
257.	A ditto, in broken masses, by computation,	23	
	Including the termination of these beds at the Black Rock House, where is the powder magazine and the forge.		

Here commences a new series, lofty, ascending from a deep valley, and here the fine oolite beds end.

*This series is called the *Black Rock*, from its being discoloured by organic remains, which probably contained much oil, as in parts where they most abound it has been collected in a liquid state. It is dark coloured and pungent, and the quarry-men make use of it for sprains and rheumatic complaints. It is a beautiful marble, both where the encrinital and coral remains are predominant, and also where it is of a deep black; and would be valued both by turners and masons were it generally known, as it takes a fine polish. Occasionally, in the centre of the beds, are found large patches of red limestone, quite irregular, and generally crossing the stratum.

At the commencement is a sharp valley; but the rocks rise at an angle of 43 degrees at least; and the first bed is a grey limestone, with encrinites, while all indeed, more or less, have this character; but in the first bed they appear most to abound at the extremities of each surface.

No.		Ft.	In.
258.	Divided into three parts inclusive, above . . . The lowest diminishing as it rises, as indeed all do, and terminating in a fine exactly even line of separation, of about one inch thick, which extends from the bottom to the summit in an angle of eighty degrees.	24	
259.	A bed quite regular but diminishing . . . . . A little upwards, the whole dark grey with occasional heads, and parts of encrinites, the lowest end a little divided in cracks.	5	6

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* Here a considerable spring issues constantly from a cavity in the bed of the river Avon, at about half low water mark. It is cold. These springs are all marks of what the miners here call Swallow-its, in the upper part of the hills, and all fail in dry weather. One of these cavities was opened at Redland three years ago, that was 200 feet long and descending; but it was a mere channel, not a reservoir.

No.		Ft.	In.
260.	A bed equally straight	4	
261.	A bed ditto	10	
262.	A bed stained with red masses	12	
263.	A ditto	12	
264.	A ditto	4	6
265.	A ditto	5	
266.	A ditto	4	
267.	A ditto	4	
268.	A ditto	3	6
269.	A ditto, much spotted	12	
270.	A ditto, darker, and mixed with red	16	
271.	A ditto	12	
	All the faces and joints of these beds are thin, sparry coloured by red and yellow marle, thickness about half an inch		
272.	A bed of the same limestone scarcely at at all subdivided even by crevices	40	
	It contains not much of the encrinite, but has the large anomia sparingly dispersed on it.		
273.	Here the rock dips into a small ravine and a new series ascends of great magnitude, commencing near the bar gate on the towing-path that divides the Sneed-Park Estate from the rocks. The first bed is very lofty and covered in part by ivy, not at all subdivided even by cracks, and measures by computation	75	
274.	The limestone similar to the black rock, coarse grey reddish, afterwards it becomes irregularly stratified and the strata broken and bent; it is about	20	
	Then follows:		
275.	A bed of ditto	8	
276.	Ditto	3	6
277.	Ditto	2	
278.	Ditto	3	
279.	Ditto	2	
280.	Ditto	2	

No.			Ft.	In.
281.	Shaley bed		1	
282.	Ditto		2	6
283.	Ditto		8	
284.	Ditto, rotten bottom		2	6
285.	Ditto, solid		6	
286.	A broken bed	These last beds are darkest.	1	
287.	Ditto, solid		2	6
288.	Ditto, broken		1	2
289.	Ditto, solid		6	
290.	Ditto		4	
291.	Ditto		5	

After this the beds of limestone disappear, being covered by soil and low woods, sloping down at forty-five degrees S.W. to the towing-path of the river Avon. The foot of the hill terminating at about three hundred yards from the lowest bed that appears above ground, from whence the woody hill rises again at the point of this second woody hill, the three last beds of this long range appear: viz.

292. The corner of a thin bed containing encrinites of a singular construction in the stem. The trochus having five perforations like a flower, also it has anomia of three species.

293. A thin pallet bed, described by Mr. Bright in his paper before the Society.

294. Another No. 16, of the same paper, being a highly ferruginous limestone.

Here terminates all that is visible of this noble section of limestone beds, perhaps not to be equalled in number, or for convenience of access.

XI. *On the Strata of the Northern Division of Cambridgeshire.*

By FRANCIS LUNN, Esq.

In a Letter addressed to G. B. GREENOUGH, Esq. Pres. Geol. Soc.

[Read May 1, 1818.]

THE tract of country examined is of an extent so limited, that I should be disposed to think the facts scarcely worth your notice, if I were not aware that it is only from the united labours of many that a perfect knowledge of the features of a country can be acquired.

The lowest stratum found in the county is the ferruginous sand, which on quitting Potton in Bedfordshire, is observed on the borders of Cambridgeshire at Gamlingay; in this parish may be seen the sand, and resting upon the sand the next stratum in the scale, the blue clay, which in this county is universally termed galt.

In some of the pits the two are seen having the line of their junction as well defined as that of two immiscible fluids, which proves that in this county there is no intermediate stratum between the sand and the galt. It may however be invariably observed, that a layer of the sand contiguous to the clay is much more highly impregnated with iron than the lower part of the same stratum, the oxide of this metal cementing together the particles of sand so as to form a hard rock. Leaving to the south-east the two villages of Hatley, which are both on the galt, we are led by the boundary of the strata between Little and Great Gransdon, and passing to the westward of Caxton, which is also on the clay, we proceed through this north-west side of the parish of Eltsley to Hilton, and thence through Passworth St. Everard to Passworth St. Agnes, and lastly arrive at Fenny Drayton ; here we are on the edge of the fens, and meet with the alluvial soil usually seen in similar situations.

Not having strictly examined the country lower within the fens, I cannot precisely state whether appearances of regular stratification again present themselves. Throughout the whole of this sand many fragments of mineralized wood are found ; when dry they generally crumble into a fine power, but when moist and fresh from the earth are definite in form, and have the bark in the utmost state of preservation.

The stratum of galt overlying the sand is of considerable extent ; it pervades the whole country from the line already traced out to the base of the Gogmagog hills ; its thickness is variable, but its irregularities may apparently all be accounted for, from inequalities of the surface of the ground, and to judge from an examination of the wells, I suppose the common surface of the sand and clay to form a very regularly inclined plane at the depth of about 200 or 220 feet from the common surface of the galt and the chalk. In the parish of Fenny Stanton a bed of clay rests upon the sand, and in the parish of Croxton the same takes place to a considerable extent. The chain well known by the name of the Gogmagog hills, consists of chalk resting on the clay ; detached masses of chalk are the Coach and Horses hill in Orwale, the summit of Madingley hill, and the Castle hill in Cambridge, which is a hummock of the lower chalk. The substances found in the clay of this county have all been discovered similarly imbedded. In sinking the few wells that pierce this stratum, splendid crystals of carbonate and sulphate of lime, with some small specimens of iron pyrites, have been thrown out. In the parish of Long Stow, near to the surface, are many beautiful septaria together with rounded flints imbedded in the clay, the septæ are formed of carbonate of lime and frequently of crystallized sulphate of barytes; the fossil cornu ammonis is also abundant.

In sinking one well in this parish, at a depth of about seventy feet, a bed of bituminous shale was cut through, of little more than an inch in thickness.

It appears possible to form some guess of the height at which the water will stand in the wells which penetrate through the galt into the ferruginous sand; for to meet with a spring the clay must be pierced. Supposing this nearly impervious bed to confine the water to the sand below, its first natural outlet is the termination of the galt and the commencement of the sand; this takes place at Gamlingay, and the level of the country being low, as might be expected, water is here found in abundance; the country is here one entire bog of variable breadth, but in some places of nearly a mile.

Many parishes are without any real well, having only such as are sunk a short depth into the clay, and into these a small quantity of water oozing forms what is termed a land spring; in Stow are three wells of which the general depth is about two hundred feet, but the water in each only rises to a certain uniform height, this (as near as can be estimated without having the exact level of the country) is the height of the outlet at Gamlingay bogs.

The one of these last sunk is on rather higher ground than the others, and is to the sand 211 feet, to the present level of the water 127; the case is much the same at Wimpole, but at Cambridge, Barton, and Hazlingfield, the water flows over the top of the well, although in some cases the sinking of a new well near to an old one, lowers in a slight degree the level of water in the latter.

XII. *Memoir on the Geological Relations of the East of Ireland.*

By THOMAS WEAVER, Esq.

M.R.I.A. M.W.S. M.R.H. & H.D.S.

[Read 15th May, 1818.]

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Introduction.

§ 1. IN the following pages I propose to give an account of the mineral constitution of that portion of Ireland, which is bounded on the east by the Irish Channel, on the south and west by the mountains which confine the Suire and the Shannon, and on the north by the hills of Louth, Meath, Cavan, and Longford, and by a line produced from thence to the bay of Galway. The tract included in this area, extends nearly 100 miles from north to south, and between 60 and 90 miles from east to west, and comprehends about a third part of the island.*

§ 2. It will be my object in this memoir, to exhibit a general view of the more prominent and important geological relations of the tract described, in the form of a condensed abstract, rather than to detail the progress of my researches. But, I shall illustrate this account occasionally by more minute description, in such parts as afford appearances either new, or more than commonly instructive: and I shall throughout abstain from indulging in the expression of speculative opinions; contenting myself with a plain description and connexion of the facts, and leaving the application of them to the reader.

§ 3. By referring to the annexed map, (see Plate 15) the physical and geological features of the several mountain chains, which occupy or traverse the field proposed for consideration, may be seen at a glance, as well as the distinct situation of individual mountains: but to illustrate more completely their general forms and their connexion with each other, I have given views of all the principal ranges, together with sections of some of the most instructive districts; (see Plates 6 and 7, and Pl. 14).* I have added views more in detail of the eastern range, leaving unnoticed no mountain of importance in that extensive tract; (see Plates 8, 9, and 10); and in all these sketches it has been my chief endeavour to preserve a faithful and correct copy of the outlines presented by nature; neglecting the subordinate considerations of ornament and picturesque effect.†

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* The miles mentioned here, and in the following pages, are Irish; which are to English, as eleven to fourteen.

§ 4. The different colours in the map mark the outline and extent of the principal formations, in ascertaining the boundaries of which no pains have been spared. The smaller subordinate formations could not be well introduced without producing confusion; but in the text I have endeavoured to supply the deficiency.‡

Form of the Surface.

§ 5. In the landscape of Ireland, there is one very remarkable feature, which cannot fail to strike every observer. In traversing

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* In all these sections, I have adopted an equal scale for altitudes and distances; so that they present a true profile of the country intersected.

† The stations, from which the views were taken, are marked on the map by asterisks and figures, corresponding with the numbers in the Plates; viz. N° 1.* to N° 18.*

‡ The bearings mentioned in the following pages refer to the Magnetic Meridian. It would appear that during the course of my observations, the variation of the needle has been partly progressive toward the west, and partly retrograde. I am indebted to the Rev. Mr. Hogg, Assistant Astronomer at the Observatory of Armagh, for the following recorded observations of the variation of the needle, made in the meridian of the observatory at that place.

Year 1799,	Dec.	27 ..	Magnetic variation,	north	west....	27°. 40′
1804,	May	10 ..	„	„	„	28 . 31½
1805,	May	14 ..	„	„	„	28 . 36
1810,	April	19 ..	„	„	„	29 . 00
1814,	March	25 ..	„	„	„	28 . 02½
1815,	Feb.	9 ..	„	„	„	28 . 01
1816,	June	17 ..	„	„	„	27 . 45½
1818,	March	17 ..	„	„	„	26 . 56

most parts of the island, we encounter ranges and groups of bold mountainous and hilly tracts, standing apart or isolated, while the interval between them is occupied almost invariably by a surface that appears nearly level when viewed upon the great scale, but which is found on nearer approach to present a gently undulated or varied line. A considerable expansion of this plain occupies the central counties of Ireland, and extends across the island from Dublin bay on the east to Galway bay on the west; and it may be affirmed, almost without danger of error, that wherever a similar plain surface is observable the base consists of flœtz limestone; to the abundance of which mineral, next to the mild temperature and genial moisture of the climate, the soil of Ireland is probably more indebted for its superior fertility than to any other cause. It is a fact deserving notice, that with the solitary exception of Wicklow, there is no county in the island in which limestone rock, either of secondary or of primary origin, is not to be found; but primary limestone appears in a great measure to be confined to the counties of Sligo and Galway, in the west, and to Donegal, Derry, Tyrone, and Antrim, in the north.

§ 6. In the map, we perceive that mountainous and hilly tracts arise above the surface of the limestone plain, on the east, the south, the west, the center, and the north.

§ 7. The Eastern chain constitutes a primary tract, extending from the north side of Dublin bay to the confluence of the Barrow with the Suire on the south; (see Plate 6, No. 2.) It forms in its higher and central part a nearly continuous mass, until it is broken through by the river Slaney; and farther south it is again interrupted by the pass of Scullogh Gap, separating Mount Leinster from Blackstairs, and by the river Barrow, which has divided the barrier that once connected Blackstairs with Brandon. The eastern flank, of the central part of this chain, presents a varied aspect; being worn into deep glens and dells, which are lined with abrupt precipices, or occupied by lakes, from whence arise those narrow transverse vallies, whose general course toward the south-east is distinguished by the most beautiful and romantic scenery. The western flank, on the other hand, presents less variety: the glens and vallies, which exhibit fewer features of attraction, being more rounded and expanded. The rivers which arise in these, have a general tendency toward a north-west direction; but, on both sides of the central range, the transverse vallies either merge into, or cut across more expanded, longitudinal vales, by which the central range is flanked, and beyond which arise offsets, or detached groups, and parallel ranges of lower hills.

The central and northern part of this chain, was formerly in a great measure impassable; presenting three openings only by which it could be traversed; namely, those of Sally Gap, Wicklow Gap, and Glenmalur, and the first two were scarcely practicable even in summer: but an easy access is now obtained to every part of the mountains by means of the excellent military road, constructed by Government since the year 1798; which commences at Rathfarnham on the north, and terminates in Aughavanagh on the south.

For the ascertained elevation of several of the principal points of this Eastern chain, I am indebted to Dr. Fitton, Mr. Richard Griffith, jun., Dr. Taylor, and Mr. Hugh Hamill, jun.; the result of whose observations, together with my own, I have thrown into the following table.*

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* Almost all of these heights were calculated from a mean of barometric observations, made with Troughton's improved mountain barometers; but a few were determined by actual levelling.

	Authorities.		
	Dr. Fitton.	Mr. R. Griffith, junr.	Above low water-mark in Dublin Bay.
	Feet.	Feet.	
Lugnaquilla	3045	3070	——
Tonelagee	. . . . . .	2696	——
Comaderry	. . . . . .	2268	——
Cadeen	2148.9	2158	——
Spynan's hill	. . . . . .	1351	——
Eadestown hill	1339.4	. . . . . .	——
Brisselstown hill	1330.1	. . . . . .	——
Kilranela hill	1295.5	1292	——
Baltinglass hill	1271.8 *	1273 †	——
Howth	578 ‡	. . . . . .	——
	Dr. Fitton and the Author		——
Garrycastle	1869.7	. . . . . .	——
Three Rock Mountain	1585.9 §	. . . . . .	——
	Dr. Taylor and the Author		
Head of Kippure	2527	. . . . . .	——
Great Sugar Loaf	2004	. . . . . .	——
Lower Lough Bray	1492	. . . . . .	——
Barracks at Glencree	1395 ‖	. . . . . .	——

* The preceding heights, referred to Dr. Fitton's authority, were ascertained in the following manner. To the elevation above Mr. Greene's house, (given by Dr. F. in his publication of Mr. Stephens's Notes on the Mineralogy of the vicinity of Dublin, p. 44), are added 193 feet, the elevation of that house above the Slaney under Tuckmill bridge, as determined by Mr. Richard Griffith, jun. together with 397 feet, the elevation of the Slaney at that point above low water-mark in Dublin Bay, as ascertained by the levels taken for the extension of the Grand Canal into the county of Wicklow, the summit level of which, Mr. Killaly informs me, would be 430 feet above low water-mark, and 26 miles in length, passing through the town of Baltinglass a little below the chapel.

† See the Fourth Report of the Commissioners on the Bogs of Ireland. Appendix, No. 10.

‡ That is 567 feet above high water-mark, to which I have added 11 feet, as the average rise of the tides in Dublin Bay, the spring tides being 14 feet, and the neap tides 8 feet.

§ Deduced from my having ascertained Ballinteir to be 338 feet above low water-mark, to which is added the elevation found by Dr. Fitton above the former place.

‖ Deduced from my having determined No. 27 Lower Baggot Street, Dublin, to be 57 feet above low water-mark, to which is added the elevation found by Dr. Taylor above the former place.

	Authorities.	Above low water mark in Dublin Bay.
	Mr. Richard Griffith, jun. and the Author.*	
†Djouce Mountain	2392	—
Little Sugar Loaf	1183	—
Bray Head	807	—
	Mr. Hugh Hamill, jun.	
Seechon	2150	—
	The Author	
Croghan Kinshela	2064	—
The highest parts of the ranges of West Aston, Dungans-town, Ballinvallow, and Kilcashel hills, the same nearly as Cronebane hill, or	1000	—
Cronebane hill	708	Above the Ovoca, a little below the junction of the two Avons.
Comaderry mountain	1567	Above the Lake of Glendalough.
Lugnaquilla	2096	Above the level of the adit of Ballinafinchogue lead-mine in Glenmalur

From these data we collect, (in so far as we may depend on the deductions taken from these numbers),

That the fall of the river	Feet	being per mile	on a line of
Avonmore, from Glendalough to the meeting of the two Avons, is	409	37 feet	11 miles
Avonbeg, from Glenmalur to the same point, is	682	76 ditto	9 ditto

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* Measured by them conjointly.

† It is thus pronounced by the people of the country, and not Douce.

	Feet	being per mile	on a line of
Ovoca, from the same point to Arklow, is . .	. . 292 . .	42 feet . . .	7 miles
Hence it also appears, that the bottom of Glenmalur stands higher than the level of the lake in Glendalough	. 273*		

§ 8. The Southern and Western chains, (see Pl. 7. No. 3, 4, 5, and 6,) partake both of the primary and secondary character, consisting principally of clayslate supporting sandstone; but the Central group is of more recent production, being composed of coal tracts, which repose immediately on flœtz limestone; (see Pl. 6. No. 2.) Of the former, I have no ascertained heights, but by comparison with the given elevations of other mountains, a practised eye may obtain a general idea of their elevation; and it appears to me that their highest points are not more than between 2000 and 2500 feet above the sea. The elevation of the Central group above the limestone plain, may be seen in the two accompanying sections, (Pl. 14. No. 1 and 4). The highest points are about 1000 feet above the level of the sea.

§ 9. The Northern boundary of our field forms a portion of that hilly tract, which rising on the south-west in the county of Longford, extends east to the bay of Drogheda, and in a north-east direction passes through the counties of Monaghan and Armagh to the north-eastern extremity of Down. This tract is composed principally of the clayslate and greywacke formation, connected with the granite and syenitic granite of the mountains of Morne, and sustaining a few isolated patches of flœtz limestone in its interior; as well as supporting, on its western and southern sides, the more extended sheet of that rock, by which it is in a great measure flanked in those quarters.

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* Glenmalur stands probably upon nearly the same level as the Glen of Imale on the western side of the central chain; for although the Slaney under Tuckmill bridge be only 397 feet above low water-mark, it is to be considered that the river has travelled a distance of seven miles from the Glen of Imale to this spot.

The Barrow at Carlow is only 162 feet above low water-mark; and therefore 235 feet below the Slaney under Tuckmill bridge.

These observations tend to shew, that the general surface is lower on the western than on the eastern side of the central part of the eastern chain; and that the general declivity on the western face of this mountain chain, is more rapid than on the eastern.

§ 10. We may obtain some idea of the general elevation of the great Limestone Plain, by considering the ascertained levels of the Grand Canal, of the Royal Canal, and the various levels taken by the several engineers who were employed in surveying the bogs of Ireland;* and for some additional data upon this subject, I have to express my acknowledgments to the Directors General of Inland Navigation in Ireland, and more especially to Mr. Killaly, their engineer.† The results are to be found in the following Table, in which all numbers refer to the level of high water mark in Dublin bay.

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* See the Reports to Parliament by the Commissioners, and their Engineers, respecting the Bogs of Ireland.

† See the Reports to Parliament by the Directors General of Inland Navigation in Ireland, and their Engineers.

A Table exhibiting the levels of the Tract occupied by Flœtz Limestone, in the interior of Ireland.

No.	Stations.	Heights above high watermark in Dublin bay.*		Authorities.
		feet.	in.	
1.	*Grand Canal*, summit level; beginning at 17 miles distance from Dublin, and continued 4 miles	264	—	Grand Canal Company.
2.	*Grand Canal*, at its junction with the Shannon at the mouth of the river Brusna	104	—	ditto.
3.	*Royal Canal*, summit level; beginning at 29 miles distance from Dublin, and continued 17 miles . . .	308	—	Directors General of Inland Navigation.
4.	*Royal Canal*, junction with the Shannon at Tarmonbarry	113	—	Mr. Killaly.
5.	*Lough Allen*,† surface . . .	146	—	ditto.
6.	*Lough Ree*, at the entrance of the Shannon	109	—	ditto.
7.	*Portumna Bridge*	89	—	ditto.
8.	*Barrow* river, at Monastereven .	181	2½	Grand Canal Company.
9.	*Barrow* at Carlow, to high water mark below *New Ross* ‡ . . .	152	—	Barrow Navigation Company.
	Ditto . . to ditto in Dublin bay	152	—	Grand Canal Company.
10.	Line of 12 miles, between the *36th Lock of the Grand Canal and Lough Ree;* being the summit level of a projected extension of this Canal .	242	—	Mr. Killaly.
11.	Line of 24 miles, between *Roscrea and Cashel;* being the summit level of a projected extension of the Grand Canal from Monastereven to Roscrea and Carrick-on-Suire . . .	398	6	Directors General of Inland Navigation.
12.	Grand Canal at *Philipstown* . .	248	—	Mr. Killaly.

* The rise of the tides being upon an average 11 feet.

† Lough Allen does not come within the tract represented in the Map. It is situate in the county of Leitrim, surrounded by a Coal Tract, which extends into Fermanagh, Sligo, and Roscommon, and reposes on flœtz limestone.

‡ The rise of the tides below New Ross is upon an average 10 feet, the spring tides being 14 feet and the neap tides 6 feet.

No.	Stations.	Heights above high watermark in Dublin bay.		Authorities.
		feet	in.	
13.	A continuation of the level last mentioned (No. 12,) on the *Western side of the Slieve Bloom mountains, and Western and Southern sides of the Bilboa mountains*	248	—	Mr. Killaly.
14.	Termination of the line No. 13, near the *town of Tipperary* . . .	326	—	ditto.
15.	General elevation of the *bogs*, in which the rivers *Barrow and Boyne arise* .	200 to 300	— —	Reports on the Bogs of Ireland, by Mr. Richard Griffith, jun. & Mr. Jones.
16.	Extremes of the elevations mentioned in the last No. Sources of the Barrow and —— of the Boyne and	189 315 218 336	— — — —	
17.	General surface of the *District South of the river Brusna*	111 to 310	— —	ditto by Messrs. Longfield, Townsend, and Edgworth.
18.	Ditto *North of the Brusna* . . .	114 to 274	— —	
19.	Ditto *bordering on the river Inny and the Shannon*	176 to 253	— —	
20.	Source of the river *Camlin* in the town of Granard (county of Longford) .	385	—	ditto by Mr. Edgworth.
21.	*Lough Ramor*, or Virginia, surface .	277	—	Mr. Killaly.
22.	*Lough Dereveragh*, surface . .	195	2	Reports on the Bogs of Ireland by Mr. Edgworth.
23.	River *Inny*, at Finnea near Lough Kinnail	199	5½	
24.	Ditto at its junction with the Shannon	108	10½	
25.	General surface, East of the Shannon, between Carrick on Shannon and Tarmonbarry; and West of the Shannon, between Roosky and Knockcroghery, (*the extremes being* 29 *and* 114 *feet* above Lough Ree, No. 6.) .	150 to 180	— —	
26.	General surface, West of the Shannon, between Lough Ree and the river Suck*	120 to 230	— —	

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* The country lying between the Shannon and the Suck, and extending from Lough Ree and Roscommon, in a direction to the west of north past Ballintobber toward French Park, consists of a high limestone ridge, which separates the streams that flow

No.	Stations.	Heights above high watermark in Dublin Bay.		Authorities.
		feet	in.	
27.	Boggy tracts, East and West of the Suck, in the southern parts of its course .	130 to 230	— —	Reports on the Bogs of Ireland, by Mr. Rd. Griffith, jun.
28.	Ditto North and West of the Suck and Ballintobber (county of Roscommon)	200 to 390	— —	
29.	General surface, between Montrath and Maryborough (Queen's county) .	268 to 404	— —	ditto by Mr. Aher.
30.	Ditto from that mentioned in the last No. (29), past *Borros in Ossory* and *Roscrea* to Newpark, 3 miles from *Cashel*, (most of this line being East of the Suire) . . highest parts	360 to 474	— —	
	lowest parts	326 to 405	— —	

Geological Relations.

§ 11. The order which I propose to follow in describing the geological relations of the East of Ireland is, to commence with an examination of the Eastern mountain chain: which, consisting almost wholly of primary rocks, will naturally lead in succession to the consideration of the transition and flœtz tracts: and as the Southern and Western chains, and the small detached range near the town of Kildare, belong in part to the last mentioned formation, I shall reserve what I have to state respecting those chains, until I enter upon the subject of the flœtz class in general.

toward the Shannon, from those which run toward the Suck; and a similar ridge occurs to the west of the Suck, dividing the waters flowing toward the Suck on the east, from those which find their vent in Lough Mask, Lough Corrib, and the Bay of Galway on the west.

I. *Primary Tracts.*

§ 12. The Eastern mountain chain comprehends by far the most interesting groups within the field of our examination; the rocks that constitute its basis being various and important, and the surface no less remarkable for the variety of its wild and picturesque beauties. My residence in the interior of this interesting country, where I took up my abode on my return from Freyberg in the year 1793, could not fail to attract my attention to the geological features around me: and I had afterwards, unfortunately, during the rebellion of 1798, and the disturbances which followed that event, an opportunity of extending my observations into the wilder and uninhabited mountainous region, in the course of the military duties, which fell to my lot as a yeomanry officer, at that unhappy period. In my farther researches also, of more recent date, the county of Wicklow afforded the centre, from whence my excursions diverged in various directions, into the remaining tracts that I am about to describe.

§ 13. The leading geological characters of the Eastern district, in its northern and north-eastern portions, have been already stated in the notes on the mineralogy of the vicinity of Dublin, published in 1811, by my friend Dr. Fitton, from the papers of the late Rev. Walter Stephens;* by whom several points of contact on the lines of junction between the granite and the slaty rocks have been correctly pointed out, and some very interesting appearances, on the northern and north-eastern confines of the granite, have been described in such a manner as to excite regret, that an observer so accurate and sagacious should have been prevented by death from the completion of his valuable researches. The reader will find that the observations of Mr. Stephens and myself, in general coincide; which is the more satisfactory, as we were mutually unacquainted with each other's inquiries: the differences are not greater, than the unfinished state of Mr. Stephens's notes will sufficiently account for; and I think it right to add, that this occasional discrepancy has induced me to pay the ~~greater~~ attention to the points, in which I found it to exist.

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* See the memoir in the Geological Transactions, Vol. I. p. 169; subsequently reprinted with additions in the Philosophical Magazine, Vol. 39. and in a detached volume. Phillips, London. 1811.

§ 14. The Eastern mountain chain is composed of formations of granite, mica slate, quartz rock, clay slate, greywacke, trap, and porphyry.

1. *Granite.*

§ 15. The granite tract supports, and is bounded in the course of its extent by mica slate, quartz rock, clay slate, greywacke, greywacke slate, old sandstone, and first floetz limestone; but gneiss constitutes no part of this mountain chain, and I have only in a few instances marked even the semblance of such a rock, in the line of junction between the granite and mica slate; as in Glenismaule, Balreagh glen, Glenmacanass, and Glenasane: and even in these cases, though there be some tendency toward parallelism in the disposition of the mica, this substance presents only discontinuous laminæ, and the remaining ingredients are granular.

§ 16. The granite region commences on the south side of the bay of Dublin, and proceeds in a continuous mass, without interruption, to Blackstairs and Brandon on the south. It occupies generally the highest portions of the range throughout, over-topping, with few exceptions, all the rest. But it is found also in the lowest position, as at the northern foot of the Dublin mountains, reaching to the bay; and it forms an extensive flat on the western side of the chain, surrounded by that bold amphitheatre of hills and mountains, which extend from the vicinity of Castle Dermot on the west, past Baltinglass, toward the foot of Lugnaquilla on the east, thence spreading to the south along the western base and brow of the Shillelagh hills. This forms the broadest part of the granite soil, being about fifteen miles across from west to east, while still more south it gradually narrows to a point, constituting however, in this quarter, not only the entire mass of Mount Leinster, and Blackstairs mountain, with its southern extension called White mountain, but forming the bed over which the Barrow flows. To the north of Lugnaquilla, the granite tract preserves a more equal and nearly uniform breadth of about seven miles, and at its northern extremity, between Rathfarnham on the west, and Dalkey Head on the east, it is nearly of the same width.

Such is the extent of that continuous tract of fundamental granite, upon which all the succeeding rocks repose. Granite, however, re-appears in other quarters; not only protruding and breaking forth in isolated, denuded portions of the great base, but occurring, as a later production, interstratified with rocks, which unequivocally rest upon the fundamental granite.

§ 17. It might seem almost an idle attempt to pursue the granite through the various modifications of its structure and aspect; but it may be observed of this extensive tract, which is full fifty-nine miles in length, that it is in general remarkably pure and free from minerals not essential to its composition. The felspar is commonly of a clear beautiful white, or slightly tinged with yellow or grey, very rarely flesh coloured. The quartz is mostly grey, and the mica in general greyish white, but it also inclines to brown or black. The granite varies much in the size of the grain. Some of the largest and most beautiful grained is found toward the northern extremity, at the Scalp, in Glencree, and at Leopardstown at the foot of Three Rock mountain; and toward the south, in the district between Borris on the Barrow and Scullogh gap. The finest grained of the fundamental granite that I have met with, occurs at the northern foot of Cadeen, in the glen of Imale. It is a remarkably close, firm, and fine grained rock, appearing almost compact; it is accompanied, however, by a coarser grained, with which it appears to alternate in layers, as may be seen in the brook which flows down the northern face of the mountain. The granite is not unfrequently porphyritic. This may be observed in almost every glen around the mountains, as in Glenismaule, Glencree, and at the head of the waterfall in Glenmacanass, where the felspar crystals acquire a length of three inches nearly, inlaid in a small grained base.

But there is one portion of the granite tract, that requires more particular attention. It is that in the vicinity of Eagle hill, Knockatomcoyle, and what are called the *White Rocks*, situated in the granite flat on the western side of the chain. In the composition of the rock at these places quartz greatly predominates, and sometimes so much so, as to exclude all appearance of granite, and to become pure quartz.

The eastern side of Eagle hill corresponds with the usual granite of the country, in the size of its grain and proportion of its ingredients; but in its summit, which forms an abrupt face to the north, quartz appears as the principal ingredient, affecting a considerable variety of aspect. On the western side are great masses and blocks of pure white compact quartz, and lower down on that side is the firm quartz rock itself. On the south again, the face of the rock is bared and the granite here appears mostly composed of quartz, the prevalence of which however becomes still more striking in the loose blocks, the felspar having decayed, and left a singularly connected tissue of quartz, exhibiting amorphous masses, veins, and ramifications.

More to the southward, around Knockatomcoyle, are great masses and rocks of very white quartz, which, although occupying a much greater space, perfectly correspond in appearance with those at Eagle hill, and hence they seem also to form inherent portions of the granite soil.

§ 18. The minerals which I have incidentally observed disseminated in the granite, or imbedded in the contemporaneous veins of granite and quartz, that traverse the rock, (which more particularly form their native seat,) are schorl, tourmaline, garnet, beryl, rock crystal, epidote, heavy spar, magnetic iron ore, galena, copper pyrites, and iron pyrites. But in addition to these, I am indebted to Dr. Taylor for the information, that he has discovered in the granite, malachite, arsenical pyrites, tinstone,* spodumene, and a new mineral, to which he has given the name of killinite.† Mr. Richard Griffith, jun. has found fluor spar on the Dalkey coast, forming druses of minute cubical crystals in small cavities in the granite; and rock crystal under the same circumstances is not of uncommon occurrence. And I have met with hexahedral prismatic crystals of felspar, 3 inches by 2, and even 4 inches by 3 in size.

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* It is an interesting fact that this metal should at length have been discovered in rock in this country, although found only in a contemporaneous vein traversing a loose block of granite; for its existence in the county of Wicklow, in the form of stream tinstone, had been ascertained several years ago by the operations of the directors of the works at Croghan Kinshela.

† Vid. The author's paper in the Transactions of the Royal Irish Academy, vol. xiii. containing a description and analysis of this mineral. I have since had the satisfaction of finding also at the south-western foot of Rochetown hill, three small blocks of granite, traversed by contemporaneous veins of large grained granite, which contain likewise killinite and spodumene.

There are few parts of the granite region in which schorl, tourmaline, and garnet, may not be casually found; but it is only casually, and in such small proportion that they must be considered as merely adventitious; and the same may be said of all the other minerals noticed. The garnet sometimes appears in the leucite form, as at Dalkey and Kilranela.

The first beryls discovered in the granite were found by me several years ago in a loose boulder at Cronebane. They were imbedded in a large grained contemporaneous vein which traversed the finer grained rock. Since that time others, as well as myself, have remarked them in several parts of the granite tract, as in Glenmacanass, Glencree, the Scalp, and more recently at the foot of Rochetown hill, where Dr. Taylor has discovered specimens of great beauty, some of them being nearly two inches in diameter. It was in this vicinity also that most of the other minerals mentioned by this gentleman were found. In Glenmacanass, near the waterfall, imbedded crystals of beryl, garnet, and tourmaline, may be frequently seen in the coarse grained contemporaneous veins of granite, and the rock itself is remarkably fine grained, and of a very firm texture.

§ 19. The granite tract abounds in contemporaneous veins of granite; and also of quartz, which however, are not quite so frequent. The former vary from the smallest to a very large grain, and in width from that of a thread to two feet. There is no glen in which the rock is at all denuded, in which they may not be studied to advantage; and no where more so than among the sublime scenery of Glendalough. In viewing this glen, from its head at the top of the waterfall, which is not less than six hundred feet above the lake, the eye takes in at a glance its whole compass, with its abrupt precipitous sides, the upper and part of the lower lake, with the hill of Castlekevin beyond. It constitutes a stupendous excavation, from one thousand to twelve hundred yards in width, and in length between two and three miles, with precipices arising on either hand, from eight hundred to one thousand feet in height. At the head of the glen, the granite forms mural precipices, and here, in the waterfall, in the bed of the stream above it, and in the high granite rocks on the north side, we perceive numerous contemporaneous veins of granite and quartz, several of which range parallel to each other in a north and south direction, while these are frequently crossed under various angles by others, which sometimes produce a heave or throw in the traversed veins. They sometimes occur so numerously in a narrow compass, as almost to resemble a kind of net work. The position of these veins is generally vertical; but in the granite rocks above Glenasane, on the line toward Luganure lead mine, I have observed veins of quartz in the granite rock in a nearly horizontal position; and the same occurrence may be remarked also on the Dalkey coast.

§ 20. The granite precipices at the head of Glendalough present no mark of stratification: they are variously and irregularly divided by cross fissures; and from the cliffs above have been detached from time to time vast blocks and masses, some of the magnitude of a cottage, which form in accumulated heaps a kind of rude shelving slope, ascending from the valley toward the firm rocks above, to the height of three hundred, four hundred, and five hundred feet.

Is granite stratified?—Is a question which has been repeatedly agitated. An attentive examination of the granite region, now under consideration, particularly where a considerable denuded surface is exposed, as in the bold precipices of the upper and lower Lough Bray, Balreagh glen, Lough Tay, Loughnahanagan, Glendalough, Glenmalur, and the abrupt sides of Lugnaquilla, leads me to conclude that the interior granite nucleus, or that which constitutes the mass of the tract, is not stratified. On the other hand, from repeated observations in the several quarries and other denuded portions, I am led to infer that the superficial parts or outskirts of this rock occasionally exhibit a disposition toward stratification.

The quarries of Golden Hill and of Glencullen, may serve as examples of this structure, the one on the western and the other on the eastern side of the granite region. In the former, the rock is divided by smooth parallel seams into strata, three, four, five, and more feet thick, ranging north and south, and dipping east 75°. The quarries are opened from seventy to eighty feet in depth, and the regular arrangement of the rock is thus fully displayed; but these strata are sometimes, though rarely, intersected by cross joints, under an oblique angle, which are mostly parallel to each other. In such cases, each stratum becomes naturally separated into tabular or columnar masses of a rhomboidal form.

In Glencullen, the rock is also divided by smooth parallel seams into great massy strata, which range 20° east of north and west of south, and dip into the mountain to the westward, at an angle of 70°. These strata vary in thickness from one foot to five, or upwards, but in general they are four or five feet thick. They are however curiously divided by other joints, which, as far as they are exposed in the quarries, exhibit a gently curved form, in the line of the direction of the strata. The same appearance prevails all the way down the eastern face of the mountain, wherever the rock juts out to the surface, particularly near the car-road leading to the quarries.

It is probable, however, that the seams which I have just described, do not descend very deep into the granite mass, or, if they do, that they become indiscernible. I observed a few years since on the Dalkey coast, a large insulated granite rock in its natural position, which the stone-cutters were gradually cutting down. It was obviously composed of parallel layers from one foot and a half to three feet and a half thick, ranging north and south, and dipping 70° east. But, although most of the seams evidently descended into the earth, some of them appeared to terminate at two feet above the ground, from which the mass protruded.

But, in general, the rock appears in the quarries, as, for example, in those of Macreddin and Glencree, to be separated by cross fissures into rude rhomboidal and other quadrangular masses; sometimes, however, there is an obvious disposition toward a spherical form, as in Knackaderry quarries, in the glen of Imale. Here the rock appears to be divided by parallel seams into strata five and six feet thick, ranging 15° south of east and north of west, and dipping 75° toward the south; but these strata are again separated by other joints in such a manner, that each stratum seems composed of rude spherical masses, surrounded and enveloped by concentric lamellar layers. I have observed a similar appearance on the coast between Seapoint and Dunleary; and between the latter place and Dalkey, this tendency toward a stratified form, or to that of rhomboidal, tabular, or columnar masses, may be frequently remarked. These appearances may be considered perhaps as exhibiting the dissection of the structure of the granite on the great scale, the distinct concretions being separated and becoming obvious by the influence of the atmosphere. Of this description are also the three protuberant rocky masses, from whence the Three Rock Mountain has its name, which bear some analogy to the granite Tors of Cornwall; and similar masses occur on granite in other countries.

2. *Mica Slate.*

§ 21. The mica slate, wherever it occurs, is in direct contact with granite, whether situate on the eastern or on the western side of the granite region. I shall first consider the eastern division, following throughout its line of junction with the granite, the most northern extremity of which is to be found in Killiney bay, and the most southern in the barony of Shillelagh, in the county of Wicklow. In the former, the mica slate leans against, and is supported by a base of granite on the south-eastern side of Dalkey-hill, below the obelisk. It occupies the coast for about 300 yards, ranging north-east and south-west, and dipping 80° south-east; and at its northern extremity granite may be seen as a sort of pediment beneath it. This mica slate consists of alternate layers of quartz and mica, from one line to two and three inches thick; and some layers of quartz extend even to two feet in thickness, while the surface of the intervening mica is almost invariably thickly studded with cruciform and stelliform aggregations of hollow spar.

South of this rock, the coast is covered by a great accumulated mass of rubble and soil, and after an interval, the granite rock reappears, some of it being very large grained; projecting in the southern part toward the sea; and on the eastern side of this projection is applied a thin mass of mica slate. To the south of this point, rubble and soil again occur, forming a depth of one hundred to one hundred and fifty feet. This accumulation, however, probably rests upon mica slate, for this rock comes forth to the day higher up on the eastern side of Rochetown road, where it supports the upper Martello tower, ranging 15° north of east and south of west, and dipping 40° toward the east of south.

On the eastern brow of Rochetown-hill, above the road, is a natural hollow in the granite, into which mica slate runs to a point toward the north, ranging north-east and south-west, and dipping 75° south-east, while to the south and south-east it expands over a part of the eastern face of the hill. The western side is formed by the granite crest of the hill above, against which the mica slate leans, while the eastern side of the hollow consists of a ledge of projecting granite rocks. The western demarcation is remarkably distinct, forming a direct line of nearly one quarter of a mile in length, the granite rising as a wall four to six feet above the mica slate in the northern part, but increasing in the southern to ten, and even fifteen feet in height. The northern, western, and southern sides of Rochetown-hill are wholly composed of granite, which protrudes in many places.

§ 22. The cultivated soil now prevents farther observation, until we ascend the hills more south, where mica slate re-appears between Shank-hill on the east, and Ballycorus and the Scalp on the west, occupying about three-fourths of the range of the hill to the north, where the fundamental granite again protrudes in that direction. On the southern side of the Scalp, the former rock is seen resting upon the latter, inclined at an angle of 35° toward the south-east, and ranging 35° north of east and south of west across the Scalp; but the general mass ranges through the hill in the direction of 20° north of east, and its dip is 40°, as shown in a pit sunk in the mica slate to the east of Ballycorus. To the south of this shaft, a boundary fence extends over the hill in that direction, in the whole line of which the mica slate is exposed, ranging as already stated. In the southern quarter, this rock is interstratified with several thin beds of fine grained granite, varying in thickness from two to six inches and more, sometimes containing minute crystals of garnet; and the same fact may be observed in the old public road, which crosses the hill on the southern side.

About thirty yards to the east of the boundary fence, we perceive naked rocks protruding to the surface, which prove to be a modification of granite, very different in structure and aspect from that of the Scalp, greyish white splintery quartz being the predominating ingredient, with which are interwoven flakes of mica, and in the quartz we observe, incidentally, a thin layer of lamellar felspar, and even crystals and disseminated portions of this mineral. The whole looks like an approximation to quartz rock, and in fact, the conical part of Shank-hill, which immediately adjoins on the east, consists wholly of that rock, and probably rests immediately on this granite.

§ 23. From the Scalp, the mica slate preserves a nearly rectilinear course to Maulin-hill and Djouce mountain, passing in its way Glenculler, through Annacriven to the west of Powerscourt, thence under the eastern side of Glasskenny, crossing Glencree river, and forming the eastern side of Balreagh glen. This glen, or rather amphitheatre, presents on the western side, bold precipices of granite, naked and abrupt, and the same rock forms the floor and about one-third part of the acclivity on the eastern side, upon which a precipitous mass of mica slate is seen reposing in a nearly horizontal position. This is the foot of Maulin-hill, which may be considered as the eastern horn of the amphitheatre.

Maulin-hill immediately faces the Great Sugar Loaf, and the view from its summit is beautiful; as indeed is the prospect from every mountain top of this romantic region; (see Plate 8. No. 8 and 9.) From this point we clearly perceive that the mica slate ranges, in the line of its apposition to the granite, almost as straight as an arrow to Rochetown-hill. It dips on the summit, towards the south-east 25°, but on the west, near its contact with the granite, only 5°. It is singularly and fantastically contorted on the small scale, and consists of alternate layers of quartz and mica, of various thickness.

§ 24. From hence, this rock crosses Glenisloreane, above Powerscourt waterfall, ascending Djouce, and constituting its summit and the whole of its eastern part. The northern and north-western sides of this mountain consist of granite, where this rock comes to the surface in several places; and by a shoulder in the northern part it is connected with War-hill, also composed of granite.

On the top of Djouce, the mica slate projects in several places, forming a kind of crest, and it re-appears lower down on the north-eastern side, ranging 25° north of east and south of west, and dipping 16° toward the south-east. At the summit it is greatly contorted, containing a large proportion of quartz, frequently in discontinuous masses, yet arranged parallel to the laminæ of the mica. From this point, the view is most extensive and magnificent, being bounded to the north only by the coast of the county of Dublin, (but in clear weather reaching even to the picturesque mountains of Morne, in the county of Down), to the south by Lugnaquilla, while to the west the eye finds an outlet through the opening made in the mountains by Sallygap, between Sorrel-hill on the south, and Seefin on the north, extending to the range of hills near Kildare; and to the east, we command the county of Wicklow on this side, with Tara-hill and part of the county of Wexford beyond. On a fine day the view stretches across the Irish Channel, being limited only by the mountains of North Wales, which, under favourable circumstances of weather, are indeed visible from most parts of this coast.

Djouce throws out an arm to the north-east, and a longer arm to the south-west, the former descending into the beautiful scenery of

Powerscourt Park and waterfall. Above the waterfall, the mica slate preserves the same character as on the summit of Djouce, but it ranges here 20° north of east, and dips 55° toward the south-east; and in the waterfall itself, the rock, over the inclined face of which the water rushes in a fall of about one hundred and twenty feet, exhibits the same dip.

§ 25. Following the Glenisloreane stream, from the waterfall downward to its junction with that of Glencree, the rock, wherever it juts out on the right and left banks, presents only mica slate; but it is soon concealed, as the banks become occupied high up by alluvial matter, partly of a calcareous nature; and these banks are beautifully clothed with wood, plantations, and the rich verdure of a cultivated soil. The mica slate, however, is probably immediately succeeded by quartz rock in the right bank, as this substance is the principal constituent of Coolakay and Long Hills, which bound the glen on this side.

§ 26. The mica slate in its progress to the south, keeps clear of Lough Tay, crosses Lough Dan, and traversing the higher part of Carriggeenduff, enters Glenmacanass a little below the waterfall, which flows down a face of granite about two hundred feet in height. From hence downward, mica slate occupies the entire eastern bank of the stream, constituting the mass of Carriggeenduff and Scar Hill; but the western bank is differently circumstanced, being lined for about one thousand yards in width by mica slate, and thence downward by granite only, until within half a mile of Laragh barracks, when mica slate re-appears for the remainder of the distance. Hence it appears that the agent which produced the glen, first broke through granite and mica slate, then followed the line of junction between these two rocks, and lastly broke again through mica slate. Somewhat similar relations may also be observed in the line of Lough Tay and Lough Dan.

The rocks on the eastern bank of the stream in Glenmacanass, below the waterfall, being cut through by the military road, we perceive that the mica slate contains frequent beds of quartz, from a few inches to two and three feet wide, and also beds of granite two and three feet in thickness, interstratified with the mica slate. One of these beds of granite contains a considerable proportion of disseminated schorl. These rocks dip 20° to 25° toward the south-east.

§ 27. The body of mica slate, on the western bank opposite, demanded farther research. I pursued its course, which led me to Tonelagee. This mountain is the most elevated point of the range which separates Glenmacanass from Glenasane. It stands on the northern side of the pass, called Wicklow Gap, and fronts Comaderry range on the south, with its granite precipices overhanging Loughnahanagan. The range of Tonelagee is composed of granite down to the head of Glenasane and the lower part of Glenmacanass; but to the east of this line is a hollow valley, on the north side of which a ridge extends from Tonelagee to Glenmacanass, forming the body of mica slate in question, and the southern barrier of Lough Ouler.

Above this lake, the brow of Tonelagee exhibits bold precipices from four hundred to five hundred feet high, and in these an arrangement is displayed that is well deserving of attention. The northern portion is wholly composed of granite, and the southern is similarly constituted, down to the arm which extends to Glenmacanass, which consists of mica slate, as already stated. In the interval, however, between the northern and southern parts of the precipice, is a body of mica slate about two hundred yards wide, with a range of 25° north of east and south of west, and dip of 70° toward the south-east, including a bed of granite that varies from six to ten yards in width, beside irregularly formed masses of the same compound, imbedded in and incorporated with the mica slate. This rock also contains occasionally small beds of splendent quartz, with a greasy lustre. The mass passes through the upper part of Tonelagee, between the summit and its northern arm, extending down to the hollow on the other side, (in which the first right branch of the King's river takes its rise), as may be seen in the several spots where it has been laid bare by the turf cutters. Hence it appears to be a prolongation of the body of mica slate at the head of Glenmacanass, gradually narrowed in its western progress, and probably tapering to an edge, so as to constitute a kind of wedge shaped mass, inserted in the body of the granite. I have met with nothing similar in any other part of the granite tract.

§ 28. The mica slate, which occupies the lower part of Glenmacanass on the western side, contains a bed of talc slate of uncertain thickness, both rocks dipping 25° toward the south east. The talc slate is of a greenish grey colour, and interlaced fibrous texture, yet disposed in laminæ, forming a slate. It is soft, yet tenacious, works easily under the chissel, and hardens in the fire, and is quarried and wrought for various purposes, chimney-pieces, hearth-stones, grave-stones, water-troughs, &c. On the surface of the stone, in the direction of the laminæ, I observed, in some cases, spots of earthy red cobalt ore, a few of which were as large as a crown piece, forming a very thin earthy coating of a peach blossom colour; but I could discover no indication of any other metallic substance, and research was not wanting for that purpose, as this place forms a portion of a tract which I hold, with two other gentlemen, under a mining lease from the See of Dublin.

§ 29. This mica slate, to the east of the glen, is connected with Scar-hill, and to the west, it forms the hill called Brocka, being the southern termination of Tonelagee range. In its farther progress to the south-west, it traverses Glenasane near the head of the glen, forms the lower and southern part of Comaderry mountain, crosses Glendolough, and penetrates through Lugduff, into, and across Glenmalur. In all these glens, in which the mica slate and granite have been broken through, we perceive a perfect parallelism in the disposition of the mica slate on either side, being inclined in its line of apposition to the granite, at an angle of 20° to 25°.

§ 30. About one hundred yards below the ridge of the lower part of Comaderry on the southern side, in a line opposite to St. Kevin's bed, are masses of trap, occupying the brow of the hill for about two hundred yards in width, and forming in the upper part a nearly continuous rock, but in the lower occurring only in accumulated or scattered blocks, occasionally intermingled with fragments of granite. The higher part consists mostly of common hornblende rock, which varies in colour from green to black, and approaches even to the nature of massive mica. About the middle of the declivity, it is intermixed with felspar, mostly compact, and greyish white, the two substances constituting a coarse-grained rock; at times the felspar greatly predominates, containing hornblende and mica disseminated in its substance. Lower down the brow, the rock consists of a compact felspar base with prismatic crystals of hornblende, interlaced, and shooting through the felspar in every direction, thus forming a beautiful assemblage. The hornblende crystals sometimes appear in stelliform groups, and the prisms extend from one to three inches in length. The exterior coating of the hornblende rock is variously affected by weathering; and in one instance, the colour of a tabular mass, about two or three inches in thickness, was thus completely altered throughout its substance, appearing of a bright pinchbeck hue. Some of the hornblende rock has much pyrites disseminated through its substance. These masses look like the wasted remains of a great bed protruding from the mica slate; but certainly not forming a continuous bed of any considerable extent, for they do not appear either on the Glenasane or on the Glendalough side of Comaderry. Two blocks of hornblende rock may be observed by the road side, leading to Glendalough, from the Seven Churches, which are probably detached portions from the same bed.

§ 31. In the precipices of Glendalough, the mica slate exhibits frequent beds of quartz, which seldom exceed three feet in thickness: and in the vicinity of the granite, it is not unfrequently traversed by numerous contemporaneous veins of quartz; but neither here nor in Glenasane, is there any appearance of alternation with granite. In Glenmalur, however, the case is very different, nearly one half of Lugduff, which borders the glen on its north side, being composed of these alternations, the study of which has in this place been greatly facilitated both by nature and art; the northern face of Glenmalur being furrowed by several ravines, and the lead mine of Ballinafinchogue being situated in this quarter. One of the best lines afforded for examining the succession of these beds is the ravine, the water from which turns the wheel of the upper smelting house. If we follow this ravine upward, making a rough measurement up the inclined face of the mountain, we find,

1.	Granite, at bottom, of uncertain thickness, upon which rests a bed of	
2.	Mica slate, that includes, however, many layers of granite, from a few to several inches in thickness, which alternate with the mica slate, forming a body	4 fathoms thick
3.	Then granite	2 fathoms ——

4. Mica slate and granite, forming an indistinct intermixture 6 fath. thick.
N.B. The preceding beds include also frequent thin layers of quartz.
5. A body of granite, the lower part of which is most curiously interwoven with contemporaneous veins of granite and quartz 15 fathoms thick
6. Then mica slate . . . . 77 fathoms —
7. Repeated alternations of granite and mica slate, forming a body . . . . 22 fathoms —
8. Mica slate . . . . 62 fathoms —
9. Granite . . . . 1 fath. 3 ft —
10. Mica slate . . . . 20 fathoms —
11. Granite . . . . 5 fathoms —
N.B. The general character of the upper beds of granite is that of granular quartz with much silvery mica, and very little felspar.
12. Hence for 50 fathoms up the ravine, mica slate alone is traceable; and again for 65 fathoms higher, up to the cattle pond, the same rock is still perceptible; and thus, Lugduff appears to be constituted to the very ridge of the mountain, through an ascent of about 120 fath. more.

§ 32. It is many years since I discovered both grenatite and emery in this ravine. Some of the mica slate contains a vast quantity of this substance, particularly the bed I have marked No. 8, generally in very small crystals, but I possess a few groups of large cruciform and stelliform crystals, well displayed in alto relievo on a tablet of the rock, by the wasted state of the surface. Of the emery I only met with a loose rounded stone, and I have not succeeded in discovering it in situ, though it is probably to be found imbedded in the mica slate.

§ 33. The relations of the rocks at Ballinafinchogue lead mine are equally interesting to the geologist and miner. The adit which unwaters and ventilates the mine, pierces the vein at a distance of 141 fathoms from the valley, and at a depth of 85 fathoms from the outburst of the vein at the surface; and with the subsequent operations carried on in the right and left wings of the mine, it has afforded another opportunity of examining the repeated alternations of granite and mica slate. If we enter this level, we find, measuring on the line of the adit,

1.	At its mouth, mica slate	1 fathom thick	
2.	Granite	3 fathoms	2 feet
3.	Mica slate	29 ——	1 —
4.	Granite	11 ——	0 —
5.	Mica slate	4 ——	5 —
6.	Granite	3 ——	5 —
7.	Mica slate	10 ——	1 —
8.	Granite	3 ——	3 —
9.	Mica slate	6 ——	4 —
10.	Granite, to the vein,	67 ——	3 —

This last bed occupies the lower part of the mine, but is the uppermost of the series above mentioned. It is surmounted by a thick bed of mica slate, above which are repeated alternations of these two rocks, as proved by the underground operations, but which, from the circumstances of the mine, do not admit of accurate admeasurement.

All these beds range uniformly 40° east of north and west of south, and dip at an angle of 20° toward the south-east; and the direction of the adit being 12° north of east and south of west, they are perforated under an angle of 38°. The vein itself intersects these beds in the direction of 25° west of north and east of south, forming an angle of 65° with the line of their direction, and of 77° with that of the adit. The ravine upon Lugduff, up which I have just supposed the reader to be conducted, is situated about 130 fathoms from the adit and higher up the glen. Hence, combining the relative position of the parts, it is obvious that many of the lower beds in the ravine cannot appear in the line of the adit, nor can several of the upper beds appear in the right wing of the mine. Again, several beds still lower are to be observed in two ravines, situated higher up in the glen to the north-west, in the farthest of which, (on the townland of Cullentrough,) we come to the fundamental granite, which, thence forward, occupies the bottom and brows of the glen; but the outgoings of the alternating beds to the north-west, may still be occasionally traced a considerable way up, in the precipices above.

From the whole of these data, I compute the thickness of these alternations to be about one-third of a mile, measuring at right angles with the dip. In their north-eastern termination, they probably abut upon the granite nucleus, being hid toward the Glendalough side by the great mass of mica slate which rests upon them, and which constitutes the ridge and eastern portion of Lugduff. In their progress to the south-west, they traverse Glenmalur, but their relations on the southern face of the glen are not easily developed, the slope being greatly encumbered with debris. They occupy however only a small district; as the continuous body of mica slate is inflected more towards the south in the upper part of the range, that divides Glenmalur from Aughavanagh.

§ 34. In descending Glenmalur, mica slate continues on either hand to the barracks at the lower part, and is often curiously incurvated and contorted; the fragments sometimes much resembling splinters of wood. It contains frequent beds of quartz, from a few inches to three feet in thickness, which may be distinctly observed in ascending the military road from the barracks toward Drumgoff hill, on the south-eastern quarter of which the granite rock reappears for a short space. The military road then passes over mica slate until within a mile and a quarter of Aughavanagh barracks, when the fundamental granite becomes again visible, occupying the whole basin of Aughavanagh, and the brows of the surrounding mountains.

The junction of the granite and mica slate may be distinctly seen in a ravine, which marks the northern face of Croghan Moira, the water from which is conducted under the military road. At this spot we may observe that the granite acquires more and more of a quartzy nature as it approaches the mica slate, becoming almost slaty quartz at the point of contact; while the mica slate itself abounds in beds of quartz of variable thickness, and the granite is traversed in all directions by contemporaneous veins of quartz of greater or less magnitude, and also by veins of granite. The mica slate, from this place, pursues its course to the northward over the mountains toward Glenmalur, forming the western border before alluded to, but in its progress to the south it passes in a south-west direction through the western arm of Croghan Moira, (called Muckla,) and crossing Aughavanagh river, penetrates Ballygobben mountain; the line of junction on both sides of the river being visible to the eye.

§ 35. From the position I have just mentioned, we perceive to the north-west Lugnaquilla, rising with its bold granite precipices above Aughavanagh, and capped with mica slate, which occupies its summit and a considerable part of its western declivity; while the steep brows around the mountain, its precipitous sides toward Glenmalur on the east, and toward the glen of Imale on the north, and its long southern arm, consist of granite. These precipices on the south side are called the South Prison, as corresponding precipices on the opposite side are called the North Prison, in both instances constituting a nook or recess in the mountain, in which the eastern border of the cap of mica slate may be observed reposing upon the granite. The summit of this mountain forms a kind of table land, presenting a smooth green sod and fine sheep pasture, and is strongly contrasted with many of its neighbours, and indeed with its own flanks, which partake more of the general character of peaty soil, abounding in heath and sedgy grass. Yet this general tract of the central mountains supports numerous flocks of sheep, and in summer even considerable herds of horned cattle also; which are sent up from the low lands, and during their summer residence thrive exceedingly on the more favourable mountain herbage. In fine weather, the summit of Lugnaquilla presents a most extensive prospect, reaching even to the Gaultees mountains on the south-west, but on this elevated spot an unobstructed view may be often hoped for in vain.

The cap of mica slate on Lugnaquilla, is also partly interstratified with beds of granite, and these alternations are sometimes traversed by contemporaneous veins of granite, as may be observed in the ravine formed by the Ballineddin stream, on the western face of the mountain.

§ 36. From Ballygobben mountain, the boundary of the mica slate forms a gently curved line in its farther progress toward the south; this rock constituting the crest and part of the western brow of the mountain range which extends through Ballymaghcrow, Carrigacrow, and the Shillelagh hills, to Aghole mountain on the south-west, and being bordered on the western side by the granite flat, to which allusion has been already made. In this quarter the mica slate runs to a point, having gradually become narrower from Croghan Moira southward; and to the south of Aghole, the granite mountains come into immediate contact with clay slate, on their eastern side.

The last mentioned portion of the mica slate tract is not wholly uninterrupted, for in the pass leading to Sandyford, between Carrigacrow hill on the north, and that of Ballybeg on the south, we perceive, on the brows of both, the granite rock denuded for a space of about four hundred yards, the eastern quarter being occupied by clay slate, the western by mica slate, in parallel order, with the usual south-easterly dip; but both to the north and south, the two slaty rocks coincide again, and conceal the subjacent granite.

§ 37. Of the line of mica slate, which we have thus traced from Killiney Bay to Aghole mountain, it may be observed in general, that its breadth, both toward the northern and southern extremities, is very inconsiderable, and that in its widest part it no where exceeds three or four miles, as it soon graduates into clay slate, by which it is bounded for the greater part of its course.

§ 38. Beside the minerals that have been incidentally noticed as occurring in this tract of mica slate, I have to mention hornblende, andalusite, hollow spar, garnet, and sphene. Hornblende, in crystals disseminated through this rock, is by no means uncommon throughout the district; and sometimes this mineral becomes so intimately mixed with the mica slate as to constitute a compact tenacious compound; as, for example, in Aghole mountain. Beds of common hornblende probably occur also occasionally in the mica slate, as detached blocks of that rock are sometimes to be seen; for instance, in the northern part of Carrigacrow, and in the lower part of Balreagh glen toward Glencree river. And, between Drumgoff and Fannanerin, a bed of hornblende slate was discovered by a trial level driven many years since. There are few parts of this tract also in which andalusite does not occasionally appear, and sometimes also hollow spar, as in Croghan Moira. But garnet, which is in general so constant a companion of mica slate, is seldom to be observed. Of sphene, the only specimen that has occurred, was discovered lately by Dr. Taylor in mica slate, on the townland of Carriglinneen, adjoining to the military road leading to Drumgoff barracks. It was in thin flakes, interlaid between the laminæ of the rock.

Western Division.

§ 39. On the western side of the granite region, the mica slate forms a variously curved line from its northern extremity, near Rathfarnham, to its southern in the parallel of Baltinglass; and the most interesting relations of this tract are to be found at these extreme points. In the northern, the line passes to the south of Montpelier-hill, crosses Glenismaule in an oblique direction, and occupies the upper part of the hollow which separates Seefiniane mountain on the east, from Seechon on the west; (see Plate 9. No. 10.) This hollow is furrowed both on the north and south side by a ravine, an examination of which presents some curious facts.

§ 40. In following the northern ravine from Glenismaule upward, we meet with granite rock alone for about three-fourths of the ascent, when mica slate appears in contact with and resting upon the granite; the strata standing nearly on their edges, ranging north-east and south-west, and dipping 75° to the north-west. In this spot, which is about one hundred yards above the first waterfall encountered in our progress, the granite exhibits some disposition toward the structure of gneiss, but to a small extent only. At the second waterfall, the mica slate is better exposed, ranging here east and west, and dipping 75° north. It contains some thin layers of quartz, sometimes pure, sometimes mixed in part with felspar. Considerably higher up the rock ranges 25° north of east and south of west, dipping as before. Beyond this occurs a bed of small grained granite in the mica slate, about six inches wide, the range and dip being the same as last observed; and within a few inches of this first bed of granite is a second of the same width, but of short continuance, terminating abruptly at the south-west, and edging out on the north-east, being thus completely inclosed by the mica slate, the laminæ of which follow the line of the bed of granite, which is about fifteen feet in length; (see Plate 13. fig. 1.)

We now come to a third bed of granite, but of less dimensions, or rather to a vein, terminating also abruptly in the mica slate, and upon its sides we perceive portions of the latter rock impressing and indenting the former in a very singular manner. Here are also layers and veins of quartz a few inches thick, either pure, or mixed with felspar, terminating likewise abruptly in the mica slate; (see Plate 13. fig. 2.)

From a curve in the direction of the ravine, the first mentioned bed of granite re-appears, and it may be followed a considerable way upward in the ravine, (the direction of the two now corresponding), sometimes contracting, sometimes enlarging in its dimensions, yet seldom attaining one foot in width.

Higher up, is a short compressed elliptical mass of granite, inclosed between the laminæ of the mica slate. It is only a few inches in length. And beyond this, is the horizontal section of what appears to be a granite vein nearly enveloping a portion of mica slate, its course being concealed by soil toward the south-west. The parallelism of the laminæ of the mica slate does not appear to be affected by this disposition of the granite; (see Plate 13. fig. 3.)

Still ascending, we find the rock ranging as before 25° north of east and south of west, and dipping to the north-west, being occasionally much disposed toward the undularly curved slaty structure. We now come to another small bed or vein of granite; (see Plate 13. fig. 4) and tracing it to the north-east, we find it abruptly cut off by a vein of granite, from four to eight inches wide, ranging 25° north of west and south of east, and traversing the mica slate, but not producing any displacement of its strata. As this vein in its direction crosses the ravine, its limits are not within view.

About twenty yards higher up, we perceive a bed of compact greenstone porphyry in the mica slate, from four to five feet wide; and lower down in the ravine is a similar bed about two feet wide.

A little higher up, a ravine comes in from the north, crossing the mica slate, which ranges here 15° north of east and south of west, and dips 52° toward the north-west; and beyond this, the firm rock soon becomes concealed by loose fragments in the brook and soil in the banks.

Mica slate occupies but a small portion of the northern face of Seefiniane adjacent to the ravine; but this face is strewed with numerous loose stones of mica slate containing schorl; and also of quartz associated with slender prisms of schorl, and sometimes also with felspar, the three forming a coarse granular compound; but in general the quartz predominates. These fragments are no doubt derived from beds in the mica slate; for lower down a bed of this kind crops out near the ravine, distinctly ranging and dipping with the slaty rock: it is about six inches wide. In the ravine itself the mica slate also appears sometimes intimately associated with schorl; and the loose fragments on the northern brow frequently exhibit crystals of andalusite; a mineral of common occurrence in other portions of the mica slate tract. Some of the beds of granite in the ravine contain minute crystals of garnet.

§ 41. The relations of the granite and mica slate are also partly disclosed in the ravine on the south side of the hollow above mentioned; but for a short distance only in the lower part, loose stones and soil concealing the greater part of the line. The first firm rock visible in descending the ravine, is granite, which lower down is succeeded by mica slate, and these two rocks then repeatedly alternate, in thick massy beds, ranging east and west, and dipping 45° north, loose fragments again preventing farther observation.

§ 42. The phenomena presented to our consideration in these two ravines, as well as in other analogous portions of the granite and mica slate tracts, seem to admit but of one satisfactory solution; that of contemporaneous origin.

§ 43. In proceeding up the south-eastern brow of Seechon, facing Seefiniane, we perceive the mica slate cropping out to the surface in strata, ranging east and west, and nearly horizontal, but dipping slightly north. The rock contains frequent layers, contemporaneous masses and veins of quartz.

In the long south-western arm of Seechon, mica slate appears soon to give place, and to pass into clay slate, containing frequent beds of greenstone, greenstone slate, and greenstone porphyry, and occasionally of quartz also. An examination of the north-western arm to its junction with the Tallow hills, presents the same results, but in a more satisfactory manner; as the rocks are bared for inspection in many places, by quarries, or by natural causes. In the lower and northern part of Seechon, particularly toward Ballinascorney Gap, the interstratified trap rocks greatly predominate, and some of them are highly crystalline. All these rocks exhibit a general range of 15° north of east and south of west, and a dip of 75° toward the south, which is in opposition to the subjacent mica slate.

Does the clay slate rest unconformably on the mica slate, or does the latter in passing into the former gradually acquire a vertical position, and at length assume an opposite inclination? The gradual change of position seems not improbable, when we consider that both rocks contain similar beds of trap, and that we have already seen the mica slate in a nearly horizontal position, inclined to the horizon under an angle of 45°, then of 52°, and lastly of 75°. I am the more inclined to this last opinion, because I have frequently remarked slaty rocks forming a curve line in their outgoings, which pursued in depth presented a directly opposite dip. It is an occurrence by no means uncommon in nature. And in the remainder of our tract, we shall observe the mica slate dipping in general only toward the east or south.

§ 44. Seechon is bounded to the north-west by the Tallow hills, and these by the Rathcool hills, and a lower range composed of Windmill hill, Athgoe, &c. extending in the same direction. But south-west of Rathcool hill is a long chain, which, for distinction sake I shall call the Rathcool range; (see Plates 6. No. 2. and 9. No. 10.) It pursues a course west of Blessington, crosses the Liffey, and finds a termination to the southward in the vicinity of Tinoran hill; but is flanked on the western side by lower ridges and offsets, which pass to the west of Kilcullen and within three miles of Athy, and terminate near Castle Dermot. This tract is more particularly composed of clay slate and greywacke, while to the eastward of this range of hills, and to the southward of Seechon southern arm, the mica slate forms in its junction with granite a varied and interrupted line. The Aghfarrel stream, the Liffey and King's rivers, break through these rocks; and thus detached portions of mica slate, in connection with granite, are visible at Golden hill and Blackmoor hill. To the south of the confluence of the King's river with the Liffey, the line is more continuous, passing through Slieve Gadoe to Black mountain, and thence to Brisselstown hill; the district lying between Tinoran and the western side of the glen of Imale, being composed principally of mica slate, which to the north gradually narrows and passes into clay slate. In the glen of Imale itself, we can trace with the eye a part of the line of junction between the granite and the mica slate, which rests upon it; namely (see Pl. 10. No. 17) in the western side of Black mountain, and in the detached portions in the form of caps, which spread down the western face of Lugnaquilla, form the summit of the picturesque Cadeen, and constitute its long north-eastern arm, and the mass of Brisselstown hill with its granite base. The glen of Imale, a basin surrounded by mountains, is founded altogether upon granite.

§ 45. The mica slate in the north-eastern arm of Cadeen seems to form a shield-shaped mass, for granite occupies the foot in every direction. It ranges 25° north of west and south of east, and dips towards the south, extending westward as far nearly as the deep inlet or hollow which marks the northern face of the mountain. The south-eastern arm and the body consist of granite, while the cap which occupies the summit and extends to the east nearly to the inlet on the north, forms a sloping line in its base, spreading low down on the northern face, beneath which, in the brook, granite is visible, supporting the mica slate; (see Pl. 10. No. 16. & 17.)

The rock of the cap ranges north-east and south-west and dips 65° south-east. It is remarkably full of andalusite, generally disposed in the direction of the laminæ of the mica, which decaying, cruciform and stelliform groups are displayed, or a confused interlaced aggregation of crystals becomes visible: but where the stone has been broken across and subsequently exposed to the action of the weather, the ends of the prismatic crystals protrude, forming lines of granular protuberances. The purest specimens of this mineral that I have obtained in the whole of the mica slate tract, were from Cadeen, in reddish or hair brown translucent crystals, with a lamellar structure parallel to two sides of the prism, which is rifted transversely; the fracture, small conchoidal or splintery. But the characters of this substance are subject to great variation from a more or less intimate incorporation with mica. Andalusite in this vicinity forms almost an essential ingredient in the mica slate, of which scarcely any specimen is wholly free from it: hence this rock acquires a varied aspect and different states of tenacity.

§ 46. Brisselstown hill and its lateral extension to the west called Spynan's hill, consist of mica slate, fine and minute granular greenstone, greenstone slate, and greenstone porphyry. Mica slate appears on the eastern side of Brisselstown, beneath which is seen the granite base, but the southern side and summit are composed of the trap rocks just mentioned, principally the two first, which form a great bed in the mica slate, while to the west this rock appears again; all these beds ranging 20° east of north and west of south, and dipping 65° toward the east. The mica slate in the western part is porphyritic, containing numerous crystals of felspar, and it passes into greenstone porphyry by an intimate mixture of hornblende. Similar relations may be observed in the banks of the Slaney, at Davidstown, and farther north toward Donard, and again in Blackmoor hill; while to the south they may be remarked in Kilranela hill. A gradation from mica to hornblende is frequently observable in these rocks; and finely disseminated iron pyrites is common in the greenstone.

Brisselstown hill forms a conspicuous feature in the landscape of this neighbourhood. Craggy protuberances stud the upper part and form the summit of the hill, which is encircled by three concentric mounds, the lowest being placed about one third down the declivity. This and the circle immediately above it, seem to have been formed, in a simple and slight manner, of loose rough stones; but the uppermost and inner circle is constructed of an immense assemblage of loose unhewn blocks, piled up to a considerable height and width, which with the crags above display a kind of mural crown, perceptible at a great distance; (see Plate 10. No. 15.) The object of these inclosures is not at present known; but, as in most uncertain cases of this nature in Ireland, they are ascribed by the people of the country to the times of the Danish inroads. They seem, however, rather referable to an earlier period; to that perhaps of the ancient worship of the country; and the craggy summit may have served as an altar.

§ 47. In a field adjoining Kilranela garden are blocks of granite containing schorl, and also garnet as large as a pea, some of which exhibits the leucite form of crystallization. Blocks of mica slate likewise occur, in which may occasionally be observed masses and small layers of garnet and quartz. Hence it is probable that this mica slate (which contains also at times a considerable quantity of hornblende) is the repository of the blocks composed of garnet, vesuvian, and quartz, found by Dr. Fitton; but I could not discover that compound in situ. In the same field also are blocks of hornblende, greenstone, and talc slate, the latter being composed of striæ disposed in stelliform aggregations, but possessing a slaty structure. I also met with a block of quartz in which were incorporated massive garnet, and epidote in acicular aggregations.

§ 48. The general range of the rocks in Kilranela hill may be taken as north-west and south-east, with a dip to the north-east, though subject to some inflections. The summit, northern and eastern sides, consist of mica slate, including in the eastern quarter a great bed of greenstone and greenstone slate: and near the summit the mica slate is remarkably contorted, dipping 30°, while in the eastern side of the hill the dip is 65°.

§ 49. In descending from the top of Kilranela hill to the south-west we cross the outcrops of the beds, and proceeding thence to Ballylug glen, at the foot of Baltinglass hill, we observe in our course a remarkable succession.

Mica slate continues to occupy Kilranela hill for some distance down the south-western declivity, when we encounter granite, under which mica slate protrudes in several places, succeeded on the surface by great blocks of granite and hornblende lying confusedly, with all their angles sharp and well defined. To the west of the plantation mica slate re-appears, which is partly porphyritic like that of Brisselstown, and some of it contains hornblende. It is succeeded by great prominent masses of common hornblende, and of greenstone, composed of compact felspar coloured by hornblende, and containing the latter substance disseminated. Beyond these rocks mica slate is again visible, and this is succeeded by granite, which occupies the public road toward Kilranela, by the side of which the two rocks come nearly in contact. All these beds may be traced in their course to the north-west and south-east, and they appear to lie in parallel order.

Ballylug glen has a direction toward the south-west. At its north-eastern extremity granite rocks project on both sides, but in descending the glen we find in alternate succession both mica slate and granite; these two forming even in this glen four principal alternations, which include several others upon a smaller scale. The position of the rocks is conformable, ranging 25° to 30° west of north and east of south. In their range the rocks appear to pass through the south-eastern flank of Baltinglass hill, which, however, is concealed by vegetable soil: and the mica slate tract continues through Baltinglass, Tinoran and Manger hills, the general range being north-west and south-east, with a dip of 60° toward the north-east.

It appears then, that the whole interval, between Baltinglass hill on the west and the western brow of Kilranela hill on the east, is occupied by repeated alternations of mica slate and granite, the former rock including a great bed of hornblende and greenstone: a view of the subject, which is confirmed by the experience of Mr. Greene of Kilranela, who in quarrying granite in the south-western quarter of Kilranela hill, encountered, to his surprise, mica slate beneath that rock.

§ 50. Mica slate does not occur again within this district till we descend considerably to the southward, on the line of the Barrow. It is spread over a small extent on the northern face of Brandon, below the summit, and is apparently unconnected with the clay slate which occurs lower down: it contains andalusite. Mica slate re-appears more to the north, about one mile above Graige on the eastern bank of the Barrow, occupying a tongue of land that projects to the westward, on the north side of which the rock exhibits massy strata ranging north-east and south-west, and dipping 65° to 70° south-east. The river in descending from this place forms a curve to the south-east, and we perceive in the section which its bank presents, that the mica slate is frequently interstratified with beds of granite in a conformable position. To the eastward of the tongue are higher granite masses, and above and below, in both banks, the same rock appears; and there can be little doubt that these alternations rest upon granite, as the fundamental rock.

3. *Clay Slate.*

§ 51. This formation is spread over considerable tracts, both on the eastern and western sides of the granite chain, and I shall first consider the western division.

§ 52. The Tallow hills, (see Plate 9. No. 10,) which bound Seechon on the north-west, consist of clay slate, greenstone, and greenstone porphyry, interstratified with each other, the latter rocks more particularly abounding in the eastern quarter. Their range is generally 10° north of east and south of west, with a dip toward the south. Rathcool hills are composed of clay slate, clay slate conglomerate, and greywacke slate, which alternate with each other, as may be observed in the quarries on the north-western brow of these hills. The clay slate conglomerate consists of angular fragments of clay slate, some nearly as large as the head, with smaller fragments of quartz, imbedded in and cemented by clay slate. The greywacke slate is of similar composition, with a small grain and fissile structure. These rocks appear in general to preserve the same range as those of the Tallow hills, but on the south-eastern side they are partly contorted and inflected. In a ravine in this quarter, they contain beds of quartz, from eight to twelve inches in thickness, and these rocks range here north-east and south-west, and dip 55° to the south-east.

§ 53. The chain of hills which extends to the southward, and which I have called the Rathcool range, is also of the same character.

§ 54. The low group, west of Rathcool, which includes Windmill hill, Athgoe, Lyons, and Rusty hills, is composed of clay slate, greywacke, greywacke slate, and granite. The greywacke consists of small and minute rounded and angular grains of quartz, numerous minute scales of white mica, small fragments of clay slate, and sometimes portions of felspar, cemented by clay slate. The greywacke slate is a similar rock, with a slaty structure; and it is the predominating rock through these hills. The rock at Windmill hill ranges 10° north of east and south of west, which is the general direction in these hills, but sometimes more toward the north-east and south-west, exhibiting also at times an undularly curved slaty disposition. The dip is toward the south-east, and generally at an angle of about 45°.

The greywacke slate of Windmill hill is remarkable for containing subordinate beds of granite. I have traced three very distinct beds, (one of them for more than forty fathoms in length) along its north-western brow, interstratified with the greywacke slate. The uppermost bed is between three and four fathoms, and each of the other two from two to three in thickness. They are respectively fifty or sixty yards apart, separated by greywacke slate; and all these rocks dip 45° to 50° toward the south-east. *

Some of these granite beds are to be traced to the westward near the turnpike road, opposite to Rusty hill. They consist of a small and fine grained intermixture of yellowish and greyish white felspar, greyish vitreous transparent quartz, and flakes or scales of mica, white and silvery, with some small scattered portions of a

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* The granite of this place has been termed by other observers a porphyritic felspar. It requires, however, only a close examination to discover the three constituents of granite in their usual state of combination. The grain, it is true, is sometimes so small, that the aid of the lens becomes necessary in order to detect its composition; but if this were a solid objection, the granite at the northern foot of Cadeeu, as well as that of many other quarters, might become subject to the loss of its title. Geology can scarcely advance in its career, unless it be generally agreed to deduce the names of rocks from their composition and structure only; without any regard to the relative position in which they may be found. I shall have occasion to re-advert to this observation in the sequel.

blackish green. The grains are sometimes so minute, that the stone appears almost compact. Sometimes also small particles and cubical crystals of iron pyrites are disseminated through the rock, which, when decomposing, communicate to the stone an iron-shot spotted appearance.

§ 55. The clay slate and greywacke throughout the whole tract to the southward, the limits of which have been already adverted to, partake more or less of the characters now described, and maintain nearly the same range and dip.

Eastern Division.

§ 56. Returning to the eastern side of the granite chain, we find clay slate spreading over a more extended space, bounded by the Irish channel on the east, principally by older rocks on the west, and stretching from the northern part of the county of Wicklow nearly to the southern extremity of the county of Wexford. To this tract belongs also the hill of Howth on the north side of Dublin bay, and likewise Irelands' Eye. In its course, it is, in different parts, associated with granite, mica slate, quartz rock, flinty slate, greywacke, trap, and porphyry.

§ 57. The strata in the northern and southern portions of this tract are in some places considerably inflected; in the middle portion they maintain a pretty uniform north-east and south-west direction, with a dip to the south-east; while the south-eastern quarter has an inclination toward the north-west.

§ 58. In the south-west we find clay slate immediately in contact with granite. It surrounds the two projecting masses of this rock, which occur between Inistiogue on the north and the confluence of the Barrow with the Suire on the south, encircles Brandon, except on the eastern side, and partly occupies the range extending toward Slievenaman on the west.

Clay slate also occupies the eastern foot of the Mount Leinster granite chain, ranging up into the barony of Shillelagh, where it forms the western side of the valley, resting on mica slate; while on the eastern side, the brows of the hills, extending from Conna mountain to Crogan Kinshela, display only granite supporting clay slate; (see Pl. 10. No. 18.)

§ 59. Granite breaks forth again in a detached and insulated portion on the south-western side of Macreddin hill, where the rock in contact with it is mica slate; this, however, soon passes into clay slate, which composes the mass of the hill; but granite re-appears at its north-eastern foot at Ballynaclash, crossing the Avonbeg and forming on the eastern side the low rocky ridge called Ballynacarrig; (see Pl. 8. No. 7.)

§ 60. This rock is again observed on the eastern bank of the Avonmore in the town lands of Ticlash, Rockstown, and Shraughmore, whence it spreads in a north-east direction through the Bola flat to West Aston, constituting the mass of this hill; (see Plate 8. No. 7.) and also the flat north of it, which extends to the eastern entrance of Deputy's Pass, and to the foot of Kilnamanna hill; and thence forming the low rocky ridge, called Carrigmore, which rises above this flat, it proceeds eastward and is connected with the western part of Dunganstown range, a slight interval only occurring between them, in which flows the Potter's river. The general characters of this granite are different from what I have met with in any other portion of the tract; quartz, comparatively speaking, seldom appears in it; the prevailing ingredients are felspar and mica, sometimes the one, sometimes the other predominating, as in West

Aston hill. The felspar is usually of a yellowish or greyish-white colour, unless when coloured greenish by mica, which mineral commonly possesses a greenish hue, and approaches sometimes to chlorite on the one hand, or to hornblende on the other. The felspar and mica are sometimes so intimately incorporated as to constitute a mineral apparently homogeneous, much resembling some varieties of trap; and in other places it sometimes verges toward clay slate in aspect and texture, as in West Aston hill and the eastern part of Rockstown. This granite sometimes acquires also a syenitic character, containing small crystals of hornblende, as in Carrigmore and Rockstown; and in the western end of Dunganstown range, called Ballynameesdagh, it passes into true felspar porphyry, exhibiting a fine granular or compact ash-grey base of felspar, in which are inlaid small brilliant crystals of hornblende and glassy felspar.

The granite of this district appears to support and to be immediately bounded by clay slate or quartz rock, but these rocks are again connected with others of an interesting character, the relations of which I shall now proceed to describe.

§ 61. In the north-western confines, the strata of clay slate of Kilnamanna hill stand nearly on their edges, slightly inclined toward the south-east, the granite rock projecting at its foot and seeming to constitute its base. In Deputy's Pass, the new line of road has been cut into this clay slate, and near the western entrance we perceive in it a bed about three fathoms wide, composed of granular felspar and mica in different states of incorporation; thus bearing some analogy to the fundamental rock itself.

In the north-eastern quarter, toward Dunganstown, the granite supports clay slate, which passes into a rock of a compound character, a base of clay slate in which are implanted angular pieces of quartz, hornstone, and crystals of felspar. This is succeeded by a bed of greenstone, which is followed by a considerable bed of quartz rock graduating eastward into hornstone, and even into compact felspar. But the central and south-eastern parts of Dunganstown hill are wholly composed of greenstone, variously modified in aspect. At the summit, it is more crystalline than in other parts, composed of distinct crystals of felspar with hornblende. But in general hornblende appears only in spots, or as colouring the felspar mass, which is partly compact and partly foliated, and in which are disseminated minute crystals of felspar. The grain varies from fine granular to compact, and the common character of the rock in the latter state is that of a base of a greyish green colour, with an uneven fracture and a tendency to conchoidal in the great, which contains disseminated minute crystals of glassy felspar. The range of these rocks is north-east and south-west. The trap is divided into strata from 12 to 18 inches thick, inclined at an angle of 80° toward the south-east. These strata exhibit a disposition toward columnar distinct concretions, each stratum being subdivided into rude irregular columns with four, five, and six sides, and the axes of these columns are parallel to the line of the dip. In the north-eastern part of this hill, the rock approaches more to the nature of an ash-grey compact felspar, partly vesicular, the vesicles being mostly empty, or slightly coated with iron ochre. These trap rocks contain occasionally disseminated iron pyrites.

The eastern and western portions of West Aston ridge are clay slate, with the same range and dip as in the adjoining country; and this rock extends to the Avonmore, nearly enclosing the granite; and accordingly, in ascending this river by the eastern bank we meet with clay slate beyond the latter rock. It contains some thin beds of hornstone and felspar porphyry; and to the north-west it rests upon a thick bed of greenstone, that incloses a bed of roofing slate, which is quarried. Beyond the greenstone, clay slate re-appears in mass for a considerable way: all these rocks ranging north-east and south-west, and dipping 65° to the south-east.

In descending the river by the same bank we find the granite immediately succeeded by clay slate and quartz rock; both of which contain here and there crystals of felspar: and these two rocks, either pure or intermixed in various states of combination, occupy the remaining part of the course of the Avonmore to its junction with the Avonbeg; and thence downward, in both banks of the Ovoca to Newbridge, ranging on the northward through Tigrony, Cronebane, Connery, and Kilmacow, toward the eastern part of West Aston ridge, and to the southward passing into Knockanode, Kilcashel, Ballymurtagh, and Ballygahan; (see Pl. 8. No. 7.)

§ 62. Cronebane is flanked on the north-western and south-eastern sides, in Connery and Tigrony, by quartz rock; which varies from granular to compact splintery, and abounds in contemporaneous veins of pure white quartz. The interval is occupied in part by pure clay slate, but principally by clay slate in almost every stage of union with quartz, from the large compressed lenticular nodules of quartz, terminating in thin edges and diffused between the laminæ of the rock, (in the direction of which they are disposed), to the smallest and most perfect intermixture and solution, graduating at length into a substance which has all the characters of hornstone and even of flinty slate; and these again pass by a series of gradations into pure clay slate; a progression which is repeated likewise on the outer flanks of the quartz rock. These quartzose varieties of clay slate abound in contemporaneous veins of pure quartz, which are more or less metalliferous. The quartz rock itself sometimes passes, though rarely, into red jasper, and even into chalcedony, as in Tigrony.

§ 63. In Croghan Kinshela (See Pl. 8. No. 7, Pl. 10. No. 18, and Pl. 7. No. 3.) granite supports clay slate; and some thousand fathoms of trenches having been cut down to the solid rock in quest of auriferous veins, the mineral structure of this mountain was gradually and fully disclosed. The western arm and brow of the mountain consist wholly of granite; and in the trench cut along the northern brow of this arm, I observed and measured the following succession and alternation of rocks proceeding eastward across the line of their direction.

No.		fathoms
1.	The fundamental granite. This is traversed at the place now described by a vein of quartz about two feet wide, containing cavities lined with quartz crystals. The rock itself is small grained, composed of yellowish or greyish white crystalline felspar, grey vitreous quartz, and blackish green mica: the felspar predominating and the mica being in the smallest proportion. At the distance of 53 fathoms from this vein is another, four feet wide, composed of white quartz with a greasy lustre and greenish grey clay slate; beyond which the granite extends forty-five fathoms farther.	
2.	Then greenish grey clay slate for	8
3.	Granite and some clay slate	11
4.	Greenish grey clay slate	149
5.	Granite	16
6.	Clay slate and granite in repeated alternations, the clay slate sometimes containing large grains of translucent quartz, and occasionally also a few crystals of glassy felspar. These alternations form a thickness of	32
7.	Granite	160
8.	Greenish grey clay slate	15
9.	Granite	21
	The predominant part of this rock and of No. 7, is greyish white felspar, with grey quartz, intermingled with spots of blackish green mica. The grain is small, and the rock sometimes much resembles the fine grained granite in the greywacké slate of Windmill hill, already described, (§ 54.)	

No.		Fathom
10.	Clay slate, greenstone, and greenstone slate, in alternation	20
11.	Ash-grey clay slate, with some small beds of greenstone and greenstone slate toward the latter part	111
12.	Ash-grey clay slate	88
13.	Greenstone and greenstone slate, constituting the body of the hill at its junction with the northern arm, and ranging to the north-east through a considerable part of that arm.	

This greenstone examined by the lens is seen to consist of minute crystals of yellowish grey felspar, intimately mixed with spots of black hornblende; its aspect to the naked eye being greenish or bluish grey, with a compact small grained uneven fracture. The compact greenstone is slaty in the great, but when approaching toward or in the vicinity of clay slate, it acquires a fissile texture.

These rocks are succeeded to the eastward by yellowish clay slate; which graduates into bluish grey clay slate, containing many cubical and some few dodecahedral crystals of iron pyrites, and traversed by numerous contemporaneous veins of quartz, both barren and metalliferous, which are frequently intermingled with chlorite.

The general range of all these rocks approaches to the north-east and south-west, with a dip to the south-east of 70° to 80°. But a local exception occurs in the two serrated peaks of this mountain; where the clay slate ranges 10° south of east and north of west, dipping in the northern peak 41°, and in the southern 38° toward the south.

§ 64. If we farther examine the line of the two Avons, of the Daragh and Ovoca rivers, we find the clay slate tract exhibiting some other relations worthy of attention.

In Ballygannon wood, on the right bank of the Avonmore north-west of Rathdrum, are two beds in the clay slate, about a furlong distant from each other, composed of granular felspar, and some iron ochre. They are each two fathoms wide, ranging through the hill to the south-west, and are quarried for building stone. In the line of the Avonbeg we perceive, on the side of the mail coach road, repeated alternations, which first appear about half a mile above the meeting of the two Avons. The clay slate contains beds, which at the first view seem to be composed of granular felspar; but a closer examination with the lens shows that they mostly consist of a very fine grained granite, the three constituents of which, are, in some places, distinctly discernible. The succession is thus:

1. bed granite, four feet wide.
2. —— clay slate, six fathoms wide.
3. —— granite, three fathoms wide, with a few intervening thin layers of clay slate.
4. —— clay slate, three fathoms wide.
5. —— granite, six feet wide, then clay slate again.

About one quarter of a mile from the meeting of the two rivers are a fourth and a fifth bed, similarly composed, each about nine feet thick, separated by clay slate, five fathoms in thickness; and a sixth, and still more considerable bed, occurs at the corner of Mr. Parnell's wood next the road.

§ 65. In ascending the left bank of the Daragh river from Kilcarrah bridge, we perceive near the mill a bed of yellowish grey compact felspar, three fathoms wide, containing crystalline felspar, and also some little hornblende and mica scattered through it. Farther on, in Templelusk, is a bed of greenstone six fathoms wide, consisting of greenish grey felspar, with hornblende and mica, and even the matter of clay slate intermixed. Some smaller beds also occur here, analogous to the former; and beyond the bounds of Templelusk wood is a similar bed, four feet wide. On the right bank of the river, in approaching Aughrim, two or three others, of a similar description, may also be observed.

§ 66. In descending the right bank of the Ovoca, we perceive between Newbridge and Knocknamohil brow, in the line of the mail coach road, two beds similar to those in the banks of the Daragh, one four feet, the other one foot wide, separated by an interval of clay slate five feet in width. At Knocknamohil brow is a bed of greenstone five fathoms wide, much of which is of a large crystalline structure. From the hill above this point, the eye commands the beauties of the banks of the Ovoca with the magnificent woody brows of Bally Arthur, Shelton, and Kilcarrah. Below Kilcarrah bridge, we encounter several other beds analogous to those already noticed. Their general characters are those of felspar, granular and compact, dotted or coloured in spots by hornblende, which decaying near the surface, the stone appears as if composed of a mixture of felspar and iron ochre. One bed about five fathoms wide may be observed a little below the confluence of the Ovoca and Daragh, and three others in approaching Kilcarrah castle. Two of these are each three fathoms wide, separated by an interval of clay slate thirty fathoms thick. The latter of these is partly intermingled with slate, and traversed by contemporaneous veins of quartz. About ten fathoms lower down is the third bed, eight feet thick. The clay slate in this quarter is in some places intersected by contemporaneous veins of quartz, nearly horizontal, the limits of which may be followed by the eye; and I have observed veins of the same description in the clay slate near Rathdrum, and in other quarters.

§ 67. In the line of the Ovoca we may remark, that although the general dip of the clay slate is to the south-east, it sometimes appears to dip to the north-west, a phenomenon which I conceive to arise in part from simple inflection, or from lenticular masses composed of concentric lamellar concretions, which, being enveloped in the general body, and abrupted near the surface, present only sections to our observation. If we could follow their limits with the eye, we should probably find the fact to be as now stated; a view of the subject, which may tend to explain the apparent inflections and contortions of rocks in general; and perhaps, the stratified structure in all its varieties may ultimately be considered as resulting from concretion on the large scale. Some observations in the subsequent part of this memoir may lead to the reconsideration of this question. We may also remark in this quarter, as well as in many other portions of the clay slate tract, that the outgoings of this rock, on the declivity of a hill, frequently present a dip directly opposite to that which it possesses at considerable depths from the surface; an instance of which kind may be observed in the road from Kilcarrah bridge to Arklow, the clay slate at this place dipping at the outburst in the soil under a low angle to the north-west, and then forming a gently curved line, it gradually acquires in depth the usual south-easterly inclination: as if the outgoings of the strata had yielded or bent toward the lower side or declivity, from a want of support.

§ 68. The left bank of the Ovoca is equally rich in beds analogous to those contained in the right bank, which appear in many parts of the noble demesne of Bally Arthur;* as in the road leading from Kilmagig to Ballycooleen, in the brow opposite to Knocknamohil point; in the road winding from the valley to the mansion above, and at the octagon, where a prospect of singular splendour and beauty bursts suddenly upon the sight. Many of these rocks at the surface contain a great deal of brown iron ochre, arising from the decomposition of hornblende and iron pyrites, and some are traversed by contemporaneous veins of quartz. The principal bed is situated in the park and occupies a breadth of about fifty fathoms, being composed of a greenstone, the hornblende of which rather predominates in the western part, while in the eastern the two ingredients are closely incorporated.

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* Not more distinguished for its beauties, than for the benevolence of its worthy possessor.

§ 69. Ballinacor hill, (see Pl. 8. No. 7,) may be considered as the south-western extremity of the *Ballinvallow* range, and Glenteigue hill as the south-eastern; the latter being situate immediately upon the coast. In the former is a bed, some fathoms wide, near the road to Arklow, which partly consists of granular felspar stained and dotted with hornblende, and in part of felspar and minute slender prisms of epidote. Glenteigue hill is wholly composed of trap, and of rocks allied to it; and in traversing the hill from west to east we perceive their connexion. On the western side, on the road leading to Redcross, we observe clay slate ranging north-east and south-west, dipping 80° to the south-east, and supporting trap in a conformable position. The composition of the clay slate at the point of junction is visibly affected by the proximity of the trap; and the latter rock to the eastward of the clay slate consists of an intimate mixture of hornblende and felspar, with much disseminated pyrites, and occasional crystals of felspar and hornblende; its colour varying from blackish green to greenish grey according to the state of intermixture. On the western brow it passes into greenstone slate; and exhibits also a tendency toward the rude columnar form. Higher up, this rock verges more and more toward felspar porphyry, and in the eastern part of the hill it graduates into a simple compact felspar. The former passes through various shades of green, grey, and yellow; the latter is mostly of a pale greenish colour, or bluish grey, or yellowish and smoke grey. Some of these varieties are slightly vesicular, the cavities being either empty, or filled with iron ochre; and where felspar much predominates, they are distinguished by the white exterior coat, so characteristic of that rock.

To the eastward of Glenteigue hill, clay slate re-appears in many places on the coast, for a distance of about two miles, ranging north-east and south-west, and dipping at a high angle to the south-east. It is visible also inland to the north of the mouth of the Ovoca.

§ 70. It may be remarked here that in following the line of the two Avons, the Daragh and the Ovoca, from the granite chain on the west to the sea on the east, we perceive the slaty rocks gradually acquiring a higher angle of elevation. In the glens, the angle of apposition is from 20° to 25°, in the meridian of Cronebane the angle of elevation is 65°, and nearer to the coast it varies from 70° to 80°. On the western side of the mountains, this order is in general inverted, the highest angle being in the vicinity of granite, and the lowest most remote from it; with this additional distinction, that the dip of the slaty rocks is commonly opposed to that of the granite declivity on the western side, while on the eastern their position is more conformable to the declivity.

§ 71. Arklow rocks are situated upon the coast one mile and a half to the south of the mouth of the Ovoca: and their connexion with the interior of the country cannot be immediately traced, the surface being occupied by a considerable depth of valuable soil. The examination of these rocks is not without interest. The northern foot of the greater rock exhibits, on the strand, large ill defined columns of greenstone, with four, five, or six sides inclined at an angle of 25° to the south-west, in which the felspar crystals and hornblende are very distinct. The northern part of the hill consists in general of greenstone, bluish grey of various shades, containing common and magnetic pyrites disseminated; but in the southern, felspar porphyry predominates, composed of a compact base of felspar tinged in some places with hornblende, and containing inlaid crystals of felspar and spots of hornblende. This last mentioned rock is at times traversed by numerous contemporaneous veins of quartz, as may be seen on the eastern side, where some of them are of short extent and terminate in slight threads. On this side also, the greenstone exhibits some small veins and interwoven portions of calcareous spar. High up, on the north-western side of the hill, in the interval where greenstone graduates into felspar, a variety may be observed, which is well entitled to the name of basalt. It is very similar to the basalt of the Giant's Causeway; a blackish grey, dense, uniform substance, close in grain, presenting minute facets variously disposed.*

On the south-eastern side of the hill, the felspar rock displays small short columnar distinct concretions, irregularly waved, with a tendency to the six-sided form, in a nearly vertical position. They much resemble those small irregular columnar concretions, into which the larger distinct columns of basalt, on the north coast of Ireland, are sometimes seen to be divided in their upper extremity, as in the western bank below the bridge at Bushmills. But in Arklow rock, they form the subdivisions of a stratum. Toward the southern end of the hill, adjoining the coast, the rock is trap conglomerate, consisting of angular fragments of the compounds already noticed, embodied in a basis of greyish felspar.

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* It may perhaps not appear superfluous to remind those philosophers, who maintain the igneous origin of basalt, that this rock is not the exclusive product of any peculiar soil, but, is, on the contrary, *the inmate of every class of rocks*. Thus, basalt is found interstratified with granite, gneiss, and mica slate. (See Charpentier's observations on the repositories of ores; a work equally interesting and valuable to the miner and geologist. See also Gerhard, Reuss, and Von Buch.) It occurs interstratified with clay slate and quartz rock. (See the observations of Gerhard, Leske, and Karsten.) It alternates with greywacke and clay slate, in the transition country on the banks of the Lower Rhine, which serves as a basis to the overlying trap formation and extinct subterranean fires. (See Nose's Travels on the Lower Rhine.) The occurrence of basalt as an inmate of the floetz class, and also as a member of the overlying trap formation, is too well known to require more than the simple notice of the fact.

The upper and southern parts of Arklow rock are composed of distinct strata from 1½ to two feet thick, slightly inclined to the south-west. These are intersected by cross parallel joints ranging north-west and south-east, inclining to the south-west, but nearly vertical; and hence each stratum becomes subdivided into rhomboidal columnar masses. This arrangement is very plainly disclosed in the great quarry on the south-western side.

The disposition of these strata is different from what we have hitherto observed in the clay slate tract. The greater and lesser rocks of Arklow, are immediately connected with each other, forming a higher and lower sub-conical ridge running parallel to the coast. I conceive this mass of trap to be enveloped in clay slate, which exists to the west, and re-appears to the north and the south at the distance of about two miles, but to possess a structure independent of the latter rock: and this independence of structure seems to be one of the characteristics of trap rock, for it may be remarked also in that which occurs interstratified with flœtz rocks. In the present case, it probably constitutes a great elliptical or lenticular mass, impressing its own form on the direction of the contiguous slaty strata. A similar disposition seems not uncommon in those tracts, in which mountain masses of quartz rock are imbedded in clay slate.

§ 72. Tara hill, (see Pl. 8. No. 7.) appears to be an analogous mass, composed principally of felspar porphyry embodied in clay slate; but its structure is by no means well exposed. It presents a rugged aspect, craggy rocks protruding above the loose stones which cover the greater part of its surface. The great body of the hill consists of porphyry, with a compact felspar base, that sometimes passes into hornstone, containing inlaid crystals of glassy felspar; but greenstone also appears occasionally. Through the felspar base the matter of hornblende seems to be diffused, its usual colour being bluish grey of various shades, and hornblende itself also appearing sometimes in indistinct spots: but this stone assumes various colours according to its relative state of disintegration; white, yellow, red, and brown, the shade of colour being lightest next the surface. In every stage of decomposition, however, it is the base only that is affected, the crystals of glassy felspar retaining their form and splendent lustre. Tara hill commands an extensive view of the eastern portions of the counties of Wicklow and Wexford.

§ 73. The county of Wexford may be generally described as consisting of high land, declining in undulating swells from the granite chain on the west toward the Slaney and the Bann; again rising on the east from these rivers into high ground, which descends toward the coast. Chains nearly parallel are thus formed, which affect a north-east and south-west disposition, as the Conna range (part of which is in the county of Wicklow), the Slieve Buy, and Bree hill ranges, the last in its extremities exhibiting isolated hills. The most southern range is that of Forth, which constitutes a rugged rocky ridge, about five or six miles in length, elevated about 500 feet above the sea, and consisting almost entirely of quartz rock, which, however, has a tendency to the slaty structure from interposed laminæ of clay slate. The strata range 25° north of east and south of west, and dip 45° toward the north-west. They are occasionally traversed by fissures, and by veins of quartz, which range 25° south of east; and in these veins have appeared in some places indications of lead, copper, and iron.

The lower grounds and eminences in the vicinity of Forth are composed of alternations of quartz rock and clay slate. The former rock, which is sometimes iron-shot and of a deep reddish hue, ranges to the north of Wexford town, forming its foundation, and in its southern progress it constitutes the *White Rocks* at Kerlogue, extending still farther south. Clay slate is visible in Johnstown deer park on the south-eastern side of Forth; and to the north-west is distinctly seen at Carrig bridge, and in several other parts around the inner haven, ranging 25° north of east, and dipping 45° toward the north-west. It is traversed by contemporaneous veins of quartz, and probably contains several beds of greenstone, blocks and fragments of this rock being observable on the strand near Saunder's Court, and smaller pieces in the fields above, and toward the entrance of Edenvale.

§ 74. The general components of the south-eastern quarter of this county are quartz rock and clay slate interstratified, disposed in the manner above described, and containing occasionally beds of greenstone. A decayed bed of the last mentioned compound may be perceived, in proceeding toward Carnsore Point, in a quarry opened on clay slate and quartz rock, close by the island of St. Ivers in the Lady's Lake. From hence to Carnsore Point, the land gradually rises, forming a low swell of ground, composed apparently of granite, great blocks of that rock, with some few scattered masses of mica slate, occupying its entire surface. The approach to a granite soil is indicated even at Broadway village, a little north of the lake, where blocks of that rock and of mica slate begin to appear.

The granite base breaks forth again in Carrigburn and Camorus hills, situated to the north-west of Forth; and blocks of granite are strewed over a part of the country, extending toward Bannow on the south. The clay slate in the southern part of the county, spreading toward Fethard and Bagenbon headland, (on which Strongbow formed his camp,) ranges in general 30° south of east and north of west, with a dip of 75° toward the north-east; yet with some inflections: but in the eastern bank of the Slaney, about six miles up the river, opposite to Bellevue, this rock ranges 10° north of east, standing nearly vertical, yet inclined toward the east of south.

§ 75. The clay slate and quartz rocks in the vicinity of Enniscorthy generally range 25° south of east and north of west, and the dip is toward the north-east, varying from 70° to 80°. About five miles to the westward, at Came, near the eastern foot of the granite chain, the strata range 20° south of east and north of west, dipping 50° to 60° toward the north-east. This portion of the clay slate tract appears to contain several beds of greenstone; and the bridge over the Urrin stream is mostly built of this rock. Traces of the same rock occur also near Enniscorthy on both sides of the Slaney. The clay slate and quartz rock in the vicinity of this town are sometimes much intermingled. Vinegar hill and the craggy rocks stretching toward Solsborough are principally composed of the latter; so also is Carrigrua (as I am informed,) situated more to the north-east. But the principal ranges, such as Slieve Buy, Bree hill, Slieve-kelter, &c. are clay slate: and quarries are opened in several parts of the line adjacent to the granite chain, some of the best slates being raised in the neighbourhood of Newtownbarry, and toward Kilkevin on the north-east. In the northern portion of the county, the clay slate ranges north-east and south-west dipping south-east.

§ 76. Before we leave this county, I may remark that a black slightly carbonated clay slate occurs near Enniscorthy, on the estate of Mr. Cookman of Bessmount, and the parts adjacent. It was there mistaken for coal, and some trials were made in consequence; and the same thing happened several years since, near the chapel of Sleighruagh in the county of Kilkenny, about two miles from Waterford, and also near Rathdrum in the county of Wicklow. Thin beds of black clay slate occur also occasionally in the clay slate of Cronebane. These rocks generally contain more or less of finely disseminated iron pyrites; and that of Bessmount exhibits also thinly interspersed galena. It is well known that substances of this description have frequently led to fallacious trials for coal in many parts of Europe.

§ 77. Returning into the county of Wicklow, we may observe a small body of quartz rock forming a prominent naked ridge, included in clay slate, on the top of Coolattin hill, but it does not there exceed 150 yards in breadth, nor does it visibly extend for any great distance: the principal depots of this rock being found in the central and northern parts of this county. The range connected with Cronebane has been already stated to consist of it; and in Carrigmacreilly range, (see Plate 8. No. 7) which is wholly composed of this rock, it is found remarkably pure. In its south-western direction it reaches almost to the left bank of the Avonmore, and in the north-eastern to the Fartrey river, forming in this quarter the picturesque rock of Cronroe. This range is flanked to the south-east and north-west by the parallel ridges of Kilnamanna and the Devil's glen, composed of clay slate, yet more or less intermingled with quartz rock. Smaller masses of quartz occur also farther north under similar circumstances, as in the defiles leading toward Newtown Mount Kennedy, and again close to Kilcool, on the north side of that village.

§ 78. But no portion of the tract presents better opportunities for examining the relations of quartz rock and clay slate, than that which extends from the north-eastern arm of Djouce mountain eastward to the coast; (see Plate 8. No. 8.) On the east it is bared by the sea; on the west it is furrowed by deep ravines, which range to the north between Long hill and the western foot of Great Sugar Loaf; and on the north it is broken through by the course of the Dargle river. On the south side of this stream we observe three great protruding masses, the two Sugar Loaves and Bray Head; and to the north the smaller one of Shank hill; all principally composed of quartz rock. They stand like monuments that have in a great degree withstood the abrading power of the elements, while their more decomposable associate clay slate, has given way. To avoid tedious repetition, I shall here present a brief summary of the mutual relations of these two kinds of rock, both in respect to composition and association, as they appear in this vicinity.

§ 79. QUARTZ ROCK. Its characteristic colour is white, usually light yellowish or greyish white; but sometimes it is more or less deeply stained yellow, red, and brown. Its exterior is often of a glazed brilliant white, as if a solution and re-consolidation of the surface had taken place. In its structure it varies from the perfectly compact splintery to the close grained granular; sometimes containing small well-defined rounded grains of quartz, which are frequently of a different colour from that of the base, even pale pink or purplish; as, for example, in the peaks of the two Sugar

Loaves, and Bray Head; but it contains very rarely rounded and angular grains of felspar, and a few scattered minute scales of mica.

The pure CLAY SLATE is yellowish, greenish, or purplish in colour, smooth, glossy, fissile, and free from admixture.

These two rocks are interstratified not only on the large but on the small scale; and it is in these alternations that reciprocal incorporation takes place; presenting rocks in some instances of an homogeneous uniform character, and in others of a distinctly compounded structure. In the former modification, quartz rock becomes tinged throughout its mass of a yellowish, greenish, or purplish colour, by an infusion of the matter of clay slate, and passes occasionally even into hornstone and flinty slate. As the proportion of clay slate increases, the compound becomes entitled to the name of quartzy clay slate; and at last it passes into pure clay slate, both compact and fissile.

The beds in which quartz predominates are of a firm compact character, and scales of mica sometimes occur, disposed without order through their mass: in the slaty beds they appear frequently arranged in the direction of the laminæ, silvering over the plane of separation.

Quartz rock impregnated with the matter of clay slate frequently envelopes grains of quartz, scales of mica, sometimes also grains of felspar, of a yellowish white or flesh red colour, and rarely, minute portions of clay slate; thus constituting a firm compact variety of greywacke; as at the northern foot of Great Sugar Loaf, in the Dargle, and in the south-eastern side of Bray Head. When clay slate matter predominates, it passes into greywacke slate.

All these rocks are more or less traversed by small contemporaneous veins and strings of pure white quartz, which in their range frequently follow the line of the dip. Quartz rock in particular is scarcely ever free from them, and they are sometimes almost innumerable.

Quartz rock, when in mass, is unstratified, but it frequently presents in this respect a deceptive appearance at the surface; being traversed by nearly parallel fissures, intersecting each other obliquely, which thus tend to divide the rock into rude rhomboidal portions. Examples of this kind may be seen in the two Sugar Loaves, and Bray Head; and in this respect we perceive some analogy to granite. It is only when interstratified with the other rocks that quartz rock appears in distinct beds; as, for instance, in the southern part of the rocky coast called the Greystones, situated about a mile and a half to the south of Bray Head.

The stratified beds in association with quartz rock exhibit, in some parts of their course, considerable inflections, both on the large and the small scale. The former are probably in a great measure derived from the shape of the inclosed unstratified mass of quartz, along the flanks of which they sweep. Thus, on the north bank of the Dargle river, a great unstratified mass occurs, flanked on either side by the stratified rocks; those on the western side ranging 15° south of east and north of west, and dipping 50° to 60° toward the north-east, and those on the eastern side ranging 30° east of north and west of south, and dipping 75° toward the south-east; (§ 71.)

§ 80. I have already observed, (§ 22.) that the quartz rock of Shank hill, on the north side of the Dargle, (see Pl. 8. No. 9.) is immediately connected with granite, and judging from the structure of this granite, it probably passes into it. But on the eastern side of Shank hill, the quartz rock appears to be associated with clay slate, the shingle of the latter being observable in the fence which ascends the hill on that side. On the south of the river, it seems to be in immediate contact with mica slate, on the eastern side of the Glenisloreane stream; for quartz rock constitutes the greater part of Coolakay and Long hills. It very soon alternates, however, with clay slate, as may be observed on the eastern side of Coolakay hill; and between Long hill and the western foot of Great Sugar Loaf, is a considerable body of purplish and greenish clay slate, with a southerly dip. On descending the eastern ravine in this quarter, (through which the principal outlet is found to the north for the waters of the marshy land on the south), we find the stratified rocks, already described, well exposed, forming in the lower part banks 50 to 80 feet high. The general range is east and west, with a southerly dip under an angle of 75°. The compact beds in the upper part of the ravine are from one to three feet in thickness, and the slaty from one to six and eight inches; while in the lower part they vary from two to five feet wide. In a few of the latter I discovered some calcareous spar intermingled with the rock, but in very small quantity. This occurrence, a similar one on the eastern side of Bray Head, and an analogous appearance in the trap of Arklow rock, afford the only instances in which I have met with carbonate of lime as a constituent in this extensive mountain tract.

§ 81. The cone of Great Sugar Loaf is steep on every side, rising under an angle of 35°. In a lateral point of view, it appears as a narrow backed ridge of a serrated aspect, 50 or 60 yards in length, rising up into a sharp crest. The cone and great body of the mountain consist of quartz rock, but in descending to the north-western flank, greenish clay slate becomes observable, dipping into the hill; and in approaching the northern face of the defile, which separates this mountain from Stilebawn hill, we encounter alternations of the rocks already mentioned. Their range is 25° north of east and south of west, with a dip of 62° toward the south-east. Stilebawn in its northern part is mostly composed of quartz rock.

§ 82. The range and dip of the stratified rocks in the Dargle, below Tinnahinch, have been already noticed, (§ 79). The compact beds vary generally in thickness from one to four feet, and the slaty from two to four and six inches.

§ 83. Below the confluence of the Dargle and Glencullen streams, glossy greyish clay slate alone appears, ranging 15° south of east, and north of west, and dipping 45° toward the south. From the granite bridge downward to Bray, a deep deposition of alluvial matter occupies the high banks on the south, and the lower grounds on the north.

§ 84. Bray Head appears to be composed of two great masses of quartz rock, the division being marked by a slight hollow in the middle part of the hill, which is occupied by the stratified rocks, ranging 30° south of east and north of west, and dipping 78° toward the north-east. But in following the rocky coast around the Head land, we find a numerous succession of stratified rocks.

On the strand, at the northern end of the Head, they range 25° north of east and south of west, and dip 42° toward the north-west. Proceeding eastward, a west section is presented to our view, in which the beds actually undulate from south to north. Farther on, they range 15° south of east and north of west, and dip 65° toward the north-east; but they are still inflected in the line of the dip, as they also evidently are in the line of the range, which may be observed in a good east section. Another eastern section is now presented, in which the rocks undulate from south to north, the range being still 15° south of east. Farther on, is a small inlet or cove, on the western side of which the rocks next the sea dip 45° toward the north-east, but more inland they begin to arch over toward the south. On the eastern side, the disposition is somewhat similar, dipping next to the sea 25°, but ascending to 50° toward the land. The general thickness of the compact beds is from one to five feet, separated by beds of greenish or purplish clay slate from two to twelve inches thick. In a second cove, which is immediately under the steep northern face of Bray Head, we find calcareous spar intermingled both with the compact and slaty beds. It traverses them also in the form of numerous small contemporaneous veins and strings, which commonly range in the line of the dip. On the western side of this cove the rocks range 25° north of east, and south of west, and dip 43° toward the north-west. They are broken to the south-east, and the line is occupied by alluvial soil, but they rise again on the eastern side and form a complete arch, dipping beyond it 52° to the south-east. Thi sarch is immediately succeeded by several distinct undulations, in the third of which an intermixture of calcareous spar may again be observed, in the form of veins, strings, and contemporaneous masses; and quartz under the same circumstances, also occurs, particularly in the compact beds.

Beds of this description, yet much shattered and broken, continue to line the coast of Bray Head, which in a great part of its course is quite inaccessible; but in the south-eastern quarter they may be approached for a short extent, ranging 15° south of east and north of west, and dipping 30° toward the north-east.

These stratified rocks ascend the northern and eastern brows of the Head a considerable way up, resting against and partly inclosing the massy unstratified quartz rock. They jut out to the surface in many places, and the line of their succession may be traced with the eye; but in ascending the hill, they acquire a higher angle in the line of apposition, reaching to 60°. The eastern face of the Head has generally an inclination of 30° toward the ocean, but the precipices next to the sea itself are quite abrupt; and this part of the coast, being little subject to the intrusion of man, is frequented by numerous sea-fowl, various species of gull, the cormorant, &c. whose melancholy cries when disturbed, are only interrupted by the resounding of the surge upon the rugged cliffs below.

The southern portion of Bray Head appears to be uninterruptedly connected with Little Sugar Loaf; but traces of clayslate are visible on the north-eastern side of the latter hill, as shown by the shingle in the soil. In the quartz rock at this place I found disseminated brown ironstone.

§ 85. The stratified rocks of the Greystones uniformly range 15° south of east and north of west, and occupy the coast for about half a mile, in the northern part of which space they are much inflected; the compact beds varying from one to two, and two and a half feet in thickness, and the slaty from two to six and eight inches. More toward the south they acquire a regular dip toward the east of north, the elevation gradually increasing as we proceed south, from 35° to 72°. Some of these beds, both of the compact and slaty, are six feet thick. In the southern part of this rocky coast, beds of quartz rock make their appearance, sometimes slightly tinged with an admixture of clay slate, and alternating with this rock of a greenish and yellowish green colour, and these beds in the dip now attain the high angle of 80°. Three of these beds of quartz rock are four, seven, and eight fathoms wide respectively, quite compact in themselves, and unstratified; but flanked by stratified rocks. If we could continue our researches to the southward, (for the coast now becomes a sandy and marly beach), it is not improbable that we should find these beds to acquire a vertical position, and at length assume an opposite inclination, toward the south; a case of this kind being observable in the line of road between

Newtown and Ashford, where the beds, which at first have a south-eastern inclination, gradually become vertical, and then as gradually approach to a north-western inclination; when, the progression being repeated, a south-eastern inclination is resumed. But partial deviations of this description should not be confounded with the general disposition prevailing in an extensive district. I have already alluded to their probable proximate cause, (§ 67.)

§ 86. After the full consideration which we have given to these rocks, the peninsula of Howth may be disposed of in few words; (see Plate 8. No. 9. and 9. No. 11. and 12.) It consists of repeated alternations of clay slate and quartz rock, both pure and intermixed with each other, so as sometimes to acquire the character of greywacke. There are not less than twelve alternations of this kind on the large scale, and the smaller are innumerable. In the larger, the quartz rock itself is in mass, and exhibits no distinct signs of a division into strata.

On the northern brow of Howth, just above the town, the beds range 40° east of north and west of south, and dip 45° to 50° toward the south-east; but to the east of the town they range 15° north of east and south of west, and dip 30° to 45° toward the east of south. In fact, we have entered at this place upon a great curve in the beds, which may be traced toward the Head-land, gradually trending more and more toward the south of east, until the range acquired remains nearly stationary, being 40° east of south and west of north, with a dip toward the south-west; as may be observed in the cliffs on the eastern and southern sides of the peninsula. The lowest beds on the north side are the flattest, and in ascending the hill the angle of their elevation gradually increases, rising to 60°, and subsequently to 70°, as may be seen along the eastern coast; while upon the southern, the angle generally varies from 70° to 80°, except in the most western part near the martello tower, where it declines to 50°, and even to 40° toward the south-west. Here also the range varies from 25° to 15° south of east and north of west.

Such appears to be the general disposition; but we have to remark also a subordinate arrangement. The great bay on the south coast is divided in its centre by a projecting ledge or promontory of rocks, elevated above the strand near one hundred feet high, and composed of compact beds from one to three feet thick, sometimes in direct contact with each other, sometimes separated by slaty beds a few inches thick. They range regularly 40° west of north and east of south, dipping 76° toward the south-west. Immediately to the westward is a small inlet, where the alternating beds, under similar arrangement, but increasing even to four and five feet in thickness, exhibit a great variety of hues, from pale ochre yellow to brownish red and purple, and from greenish white to lavender blue; forming on the large scale a curious and striking assemblage sf colours, disposed much in the manner of those of ribbon jasper. In the centre of this inlet, and a little west of the variegated beds, the stratified rocks display a different structure. Each stratum forms a sharp edged trough, the sides converging, and the one stratum is inserted in the other, so that each bed dips on the eastern side of the trough toward the south-west, and on the western side toward the north-east. The stratified rocks preserve this north-eastern dip and retain their parallelism for some little distance to the westward, when the preceding arrangement is repeated, but in reverse order, the beds now forming inverted troughs with the keel uppermost; so that the same beds dip on the eastern side of the troughs to the north-east, and on the western side to the south-west. In both these cases, the section presented is vertical, but to the east of the projecting ledge we may observe, at low water, an horizontal section also, in which the beds form curves converging one within another; whence it would appear that the series constituted at one time great lenticular masses, composed of concentric lamellar concretions, enveloped in the general body. I consider these as instructive appearances, tending to explain many of the flexures in strata, the limits of which we have not an opportunity of following with the eye; (§ 67.)

The beds on the western side of this inlet become gradually mixed with quartz, and at length pass into quartz rock; and at the very point projecting toward the sea, we meet with a body of fine compact greenstone porphyry, flanked on either side by quartz rock, which also on the southern side forms high peaky rocks, standing out into the sea. The porphyry itself is visible only at low water, being nearly covered by the sea and inaccessible at flood tide. It appears to range and dip conformably with the quartz rock, and to form a bed eight fathoms wide in the broadest part, which is in the south-eastern quarter, in which direction it is soon concealed by the sea; but in its progress to the north-west it separates into two branches, each three to four fathoms wide, and the interval between them is occupied by quartz rock, which they probably inclose, coinciding again to the north-west. This, however, cannot be determined with precision, as the continued line of junction is not visible, although the porphyry is perceptible for thirty or forty fathoms farther to the north-west, encumbered and partly concealed by loose masses of rock, beneath which and the sea it at length disappears.

To the west of this projecting point is another small inlet, in the eastern quarter of which the rocks range 40° north of west and south of east, dipping 70° toward the south-west; but in proceeding westward, we meet with a repetition of the same inflections that we noticed in the inlet to the eastward. First the erect, and then the inverted trough, accompanied also with an horizontal section visible at low water, shewing the continuity and convergence of the several layers one within another. I apprehend that similar concretions are also more or less distributed through the body of the hill; as in the upper parts I have occasionally remarked flexures and variations in the line of dip, which do not seem to admit so readily of explanation on any other principle.

On the western side of this inlet, the stratified rocks have resumed their south-western dip, at an angle of 82°, ranging 30° west of north and east of south. The western point itself is composed of massy quartz rock: and along this coast the promontories are commonly of a quartzose nature, the sea having made its inroads and formed inlets mostly in those parts, where the rocks were of a more perishable composition.

In the great quarries opened on quartz rock in the northern face of the Headland, for the construction of the piers and new harbour at Howth, I have occasionally remarked disseminated small portions of iron pyrites, copper pyrites, arsenical pyrites, and galena. In the quartzy clay slate, near the Great Light-House, I met with fibrous brown hæmatite; and grey ore of manganese, brown ironstone, and earthy black cobalt ore, have been found on the south-western side of Howth. The discovery of the last mentioned substance is due to Dr. Stokes, Professor of Natural History in the University of Dublin.

This diffusion of metallic substances through the mass of rocks, is a phenomenon much more general than is commonly supposed, although the particles are, from their minuteness, frequently imperceptible to the eye; and it may serve to explain why quartz rock on exposure acquires on its joints and fissures so great a variety of tints, becoming more particularly discoloured by a dirty yellow, brown, or red. In the same manner the variegated colours of the stratified rocks on the southern coast may be in part accounted for.

§ 87. Ireland's Eye, (see Pl. 9. No. 14.) may be considered as a dismembered portion of Howth. The south-eastern angle is a confused intermixed mass of clay slate and quartz rock, the former predominating, much iron-shot, and partially decomposed. The stratification is not regular, but mostly disposed in a north-east and south-west direction, dipping 50° toward the south-east. But the mass of the island to the north, that is to say, the whole upper region and ridge down to the water's edge on the north, east, and west sides, consist of massy quartz rock, without any appearance of stratification. It betrays its usual characters, which have been already developed.

§ 88. In the whole expanse of the clay slate formation, the description of which I have now concluded, I have never perceived, either on the western or on the eastern side of the granite chain, the slightest vestige of organic remains. Hence, I cannot subscribe to the application of the term *transition*, which has been bestowed upon some of these rocks, as well as upon the analogous tracts of clay slate in other parts of Ireland; conceiving as I do, the essential distinctions of the formations, properly to be considered as intermediate between the primary and the floetz classes, to consist not only in the nature of the rocks themselves, but also in the circumstances of their relative position, and in their containing the remains of organized bodies; and being consequently of opinion, that neither the mere occurrence of matter mechanically divided in the composition of rocks, nor the curvatures or inflections which their strata sometimes display, entitle them to a place among the transition formations: for these are characters common to all classes of rocks, in a greater or less degree. And in the case before us, we have seen that the rocks in question are connected by insensible gradations with mica slate, and even with the fundamental granite itself.*

Metalliferous Relations of the Eastern Mountain Chain.

§ 89. The Eastern Mountain Chain, the leading features of which we have now examined, is remarkable in one respect,—the total absence of metals on the western side of the granite region, while an abundance of them exists on the eastern. The metallic repositories, found in the latter, I shall consider in two divisions, founded upon natural distinctions; those in the granite and mica slate tracts appearing in the form of true veins, with a single instance of a metalliferous bed: and the clay slate tract containing only beds and contemporaneous veins, or alluvial deposits. In each of these divisions, I shall take an historical view of the metallic repositories discovered and wrought; conceiving records of this nature to be highly useful, both to present and future inquirers.

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* Saussure, in his Agenda, chap. xv. No. 16, asks "Est-il bien constaté, comme j'ai crû le voir dans les Alpes, qu'il existe des poudingues ou grès, sinon primitifs, du moins d'une formation antérieure à celle de toutes les autres pierres secondaires?" If any doubt as to this point could remain in the mind of the reader, after an attentive perusal of the engaging and instructive *Voyages dans les Alpes*, it must be removed by the researches of later observers in the same regions, as well as in distant quarters of the earth; particularly by those of Von Buch. But it has unfortunately been the fashion, both on the Continent and in the British Isles, to designate the rocks of a particular tract by the name of *transition*, whenever any of the component members happen to possess characters indicative of a mechanical origin, although in all other respects coinciding with those belonging to the primary class; and it is this practice that I deprecate, as tending to confound things otherwise distinct. Werner, the great founder of Geology as a science, certainly generalized too rapidly, when he excluded all mechanical agency in the production of primary rocks; for though the general rule be true, that primary formations are of chemical origin, numerous exceptions undoubtedly occur, in which the effects of mechanical disturbance are plainly to be descried: as, on the other hand, secondary formations, though commonly possessing prominent and unequivocal marks of mechanical origin, are not unfrequently accompanied by such as are simply the results of chemical affinity.

1. *Metalliferous Relations of the Granite and Mica Slate Tracts.*

§ 90. The lead vein at Dalkey, which is situated near the north-east extremity of the tract, appears to range in the granite north-west and south-east, dipping 70° to the north-east. The outburst of the vein is visible near the shore, where it is from four to five feet wide, composed principally of disintegrated granite, with quartz, in which some little green lead ore is perceptible; but among the refuse of the mine we may observe also galena, blende, and heavy-spar. The vein does not appear in the hill above; and hence it probably takes a turn more toward the north, following the hollow which separates Dalkey Hill from the headland. This mine is at present filled up with the sea water.

§ 91. At Ballycorus (§ 22.) are two veins, the general range of which is north-west and south-east, one dipping to the north-east and the other to the south-west. At the surface they coincide, but diverge as they descend, and also in the line of direction, both to the north-west and south-east. In the latter case, the southern vein ranges 44° east of south from the point of junction, while the northern pursues a course 12° south of east. In the fork is granite, but, a little beyond it, both veins penetrate and range in mica slate; yet in depth they descend into the granite, which rock alone is traversed in their north-western course.

The workings opened upon these veins extend about 110 fathoms in length, and in the deepest part 22 fathoms, at which depth the northern vein is about 3½ fathoms distant from the southern vein. They had been pursued into the mica slate about 10 fathoms only. Their most productive part was at the place of meeting, near the surface. The north vein varies in width from a few inches to one and a half and two feet, in some places enlarging to the breadth of four or five feet; and on this the deeper workings have been conducted, the south vein being less productive of ore, and in general only from a few inches to one, or one foot and a half thick. The veinstones are quartz and heavy-spar, which bear ore in short bunches from a few inches to one and two feet in width, and in length from one to three feet, consisting of fine grained galena, which yields 75 per cent. of metal, accompanied by some white lead ore, and occasionally by blende and pyrites.

§ 92. To the west of Lough Dan is a vein which traverses the granite brow of Carriggeenduff, (§ 26.) and, ranging across the valley, penetrates Knocknacloughole mountain on the north. It has been opened by two levels near the northern foot of the former mountain, one about fifteen fathoms above the other, and forty-eight and thirty-six fathoms in length respectively. The vein is in general from three to four feet wide, and dips 80° toward the east, consisting of quartz, with a regular *sticking* or layer of soft tenacious clay (the German *besteg)* on the western side, and containing galena either in bunches or disseminated, and occasionally also a small quantity of copper pyrites; but the greater part of it, as far as explored, appears to be barren. This vein does not seem to penetrate the mica slate, which to the southward forms the upper part of Carriggeenduff; four trenches cut into that rock in search of it, ten fathoms asunder, and across the direction of the vein, not having been attended with success.

§ 93. At the head of Glenasane, (§ 29.) a little above the junction of the granite and mica slate, and at the foot of the waterfall, a vein appears, being bared for a short distance by the torrent, but surrounded on every side by loose blocks of granite. It consists of quartz with some granite intermixed, six feet wide, accompanied on its western side by a leader of blende from three to six inches wide, containing disseminated copper pyrites, but some lumps of galena occur in a string of quartz which diverges from the vein. This vein ranges 18° south of east and north of west, and dips 60° toward the south. The rock here is granite, and the vein in its direction points to a hollow in the high granite precipice of Comaderry, which faces Glenasane on this side, and were it continuous for a mile, it would come in contact with Luganure vein to the westward.

§ 94. I have opened a mine in Luganure vein, on the northern side of Comaderry, (§ 29.) by a level driven to the southward, on the vein, for a distance of near two hundred fathoms; and it has been proved by adequate trials, that this vein completely intersects Comaderry mountain, through which it ranges, first up the northern declivity in the direction of 30° east of north and west of south, then over the ridge 17° east of north and west of south, and lastly down the southern declivity in a line parallel to its former range. It is here intercepted by the powerful Glendalough vein, hereafter mentioned.

Luganure vein runs wholly in granite, passing about twelve fathoms below the summit of Comaderry, on the eastern side. Its ascertained course exceeds nine hundred fathoms, and its depth one hundred and eighty fathoms. The adit level driven in on the north side would attain a depth of ninety fathoms from the surface, and the vein re-appears at nearly the same level on the south side, while about ninety fathoms lower down it encounters Glendalough vein, among the granite precipices. So far as hitherto explored, this vein appears in general to be five feet wide, but in one place it is enlarged to the breadth of twelve feet. It dips 65° toward the west. The predominant veinstone is quartz, which is firmly adherent to the hard solid eastern granite wall; but on the west or hanging side, (which, however, is also smooth and well defined), the granite, though to the eye it appears firm, is commonly soft, giving way to the pressure of the fingers, and it is thus sometimes affected for a distance that varies from a few inches to two and three feet from the vein, where the rock at length resumes its usual degree of solidity. Between the hanging wall and the vein, is a sticking, and between this and the quartz mass on the eastern wall, the ingredients present various degrees of solidity, being sometimes quite loose, sometimes very compact. They frequently consist of well defined fragments of firm or of softer granite, more or less consolidated and cemented by quartz, heavy-spar, blende, and galena. Heavy-spar occurs however only in small quantities, and chiefly toward the hanging wall; and fluor-spar I have observed only once disseminated in quartz, or in small cubical crystals of a pure white colour, occupying with quartz crystals a cavity in the quartz, which at times abounds in drusy holes, or *lough-holes* as they are called by the miner, from their frequently containing water.

This vein has yielded, in some parts of its course, in the cubic fathom, from three to four and a half tons of galena, which appears either in layers parallel to the walls, or in disseminated masses. The former are more particularly confined to the eastern side: white lead ore also occasionally appears in acicular crystals, and likewise green lead ore, but the latter is seldom found except near the surface. Blende is not uncommon, and copper pyrites appears casually disseminated. This vein is very regular in its range and dip, but less certain in its produce, the ore of which yields 70 per cent. of metal.

To the westward of Luganure vein is another vein in the granite, at the distance of a few fathoms, appearing in the brook. It dips also toward the west, ranging 35° east of north and west of south, and hence it probably converges with Luganure vein toward the north. It is three feet wide, consisting of quartz which contains lumps and disseminated portions of galena, and also of white and green lead ores.

§ 95. Glendalough vein ranges east and west, crossing the glen in an oblique direction; (§ 19. 29.) Its course may be pursued with the eye down the precipitous southern brow of Comaderry for a considerable distance, its southern side being denuded in several places, and standing like an erect wall, twenty to thirty feet high. In its range across the glen, it is lost beneath the mass of debris accumulated in that quarter, but it re-appears high up on the other side, to the south of the waterfall. The line in which it may be traced is about half a mile; but to the west it probably ranges far up into the granite of the interior; while to the eastward it does not seem to extend much into the mica slate, not appearing, as might otherwise be expected, in the precipices on the Glenasane side. By various trials in different parts of its course, I have ascertained this vein to be from five to seven fathoms in width, with a smooth parting or sticking on the south side. The great mass is quartz, varying from a very coarse to the most crystalline structure; sometimes exhibiting a congeries of balls or spherical concretions, composed of columnar concretions converging to a common centre. These balls I have also found in the centre of a mass of galena; and similar appearances may likewise be remarked in the vein at

Luganure. The quartz mass of Glendalough vein abounds in occasional cavities, sometimes lined with quartz crystals, and more or less filled with clay, iron ochre, or white lead ore, which latter substance occupies also fissures in the quartz. The vein bears likewise galena, copper pyrites, sparry iron ore, and heavy spar, which appear irregularly disseminated through the mass, or forming discontinuous ribs and strings. Traces of blende and iron pyrites also occur. On the south side of the waterfall it consists principally of quartz incorporated more or less with sparry iron ore, containing massive and disseminated copper pyrites, of good quality.

The lead ore of this vein produces 70 per cent., and the copper ore from 10 to 15 per cent. of metal; but the galena was obtained in a continuous mass in one part only. It was found, to the amount of about a ton in weight, near the surface, where the vein first enters the mica slate, and it was there I discovered, in blasting, those fragments of mica slate imbedded and firmly consolidated with the veinstone, of which fig. 5, Pl. 13. is a representation. The surface here depicted is about four feet wide, which I left untouched, for the gratification of future visitants. The very position of these fragments bespeaks disturbance, for scarcely any two of them perfectly agree in the relative disposition of the laminæ. To a similar disturbance may also be ascribed the occurrence of the granite fragments, already mentioned, in the mass of Luganure vein.

§ 96. In the waterfall, at the head of Glendalough, is a vein of quartz about one foot in width, which abounds in cavities lined with quartz crystals, and partly occupied with iron ochre and some disseminated copper pyrites. This vein has regular smooth walls, and ranges in the granite 30° west of north and east of south, traversing the numerous contemporaneous veins of granite and quartz, which it encounters in its course. And high up in the ravine, to the south of the waterfall, is a small vein about six inches wide, which ranges north and south in the granite, and consists of quartz bearing copper pyrites of good quality. Both these veins, in their progress to the north, come probably in contact with Glendalough vein.

§ 97. Following this stream upward from the waterfall, at the distance of about one mile and a half from Lough Finogefin, we meet with a vein on the western side of the stream, composed principally of quartz with some lamellar heavy-spar and iron pyrites; but so little is exposed that its relations are uncertain.

§ 98. The direction of the lead vein at Ballinafinchogue in Glenmalur (§. 33.), forms an acute angle with the course of the valley, ascending in its progress to the south-east the northern brow of the glen. It has been traced for a distance of about four hundred fathoms, but probably extends farther. As far as known, however, it is confined to the alternating beds of granite and mica slate. It is inclined for more than forty fathoms from the surface to the southward, under an angle of 80°; but for the remaining depth to the adit level the dip is northward at the same angle; so that it may be considered upon the whole as vertical. The width varies from two to three fathoms, and the mass is composed of quartz, attended more or less with loose vein soil on either side, and with a thin coat of clay or sticking next the walls. The ore has been principally obtained on the south side of the vein, but it occurs also on the north side, and even in the central part; so that three deposits of galena have appeared within it, which, when they coalesce, have formed considerable bodies of ore. White lead ore, both massive and crystallized, also occasionally appears, with blende, copper pyrites, iron pyrites, and heavy spar; but these are comparatively of rare occurrence, quartz and galena being the principal constituents.

The connected workings upon this vein extend about 160 fathoms on its range; the wing of the mine to the right of the adit being one hundred fathoms, and that on the left sixty fathoms in length. The annual produce of ore, during a course of several years, has been from three hundred to four hundred tons of galena, which yields on an average 68 per cent. of lead; and it is worthy of observation that the vein has proved much the most productive in that part, where it traverses a very thick bed of mica slate. The ore is smelted in a simple and cheap manner in small blast furnaces, with the aid of turf, lime, and a small proportion of the purest blind coal that can be procured; and being reduced at a single operation, the lead obtained is of an excellent quality, fit for every purpose of the plumber. In the adit level, about eighty fathoms from its mouth, a vein was crossed about three feet wide, consisting of quartz, and containing some disseminated galena and iron pyrites. It ranges 20° south of east and north of west, inclining toward the north-east. In its progress to the eastward, it would, if continuous, traverse Ballinafinchogue vein under an angle of 45°, about fifty fathoms to the east of the adit; and it appears in fact to do so, but in the form of a fissure only, which, however, is probably its eastern termination, as it agrees in range and dip with the vein in the level. It is very remarkable that beyond this fissure the lead vein has proved in a great degree unproductive.

The lead vein in its progress to the north-west crosses the ravine, which we formerly ascended from the smelting-house (§ 31.), and there encounters a strong vein of quartz, containing sparingly disseminated galena, which may be traced some distance down the ravine, standing like a wall, the decomposed mica slate on either side having been washed away by the mountain torrent. This vein ranges 10° south of east and north of west, dipping 70° toward the south, and forming in the line of its direction an angle of 55° with that of the lead vein: but the relations between these two veins, at the point of contact, have not been ascertained by operations underground. In the ravine we perceive considerable disturbance, and the loose mass of vein materials, quartz, heavy-spar, galena, blende, pyrites, and soil, occupy several fathoms in width. I apprehend, however, that the lead vein traverses the vein in the ravine, for the former has been cut in the due line of its range to the north-west, about 130 fathoms beyond the latter, and in attempting to trace this vein up the hill on the other side of the lead vein, it appears to me to be thrown two or three fathoms to the northward: a dislocation, which may tend to explain the great breadth of vein stuff at the point of intersection.

§ 99. By ascending the ravine, situate farther up the glen, in which the fundamental granite first decidedly appears, we find the mica slate in contact with it; (§. 33.) and between the two rocks there is interposed a bed of quartz, from one and a half to two feet thick, following in its range and dip the line of junction. This bed of quartz bears galena, and has been worked five or six fathoms in length, and twice as much in depth, but the operations were not attended with advantage. It is remarkable, as being the only metalliferous bed that has occurred in the tract.

§ 100. In the waterfall at the head of Glenmalur, a vein of quartz may be observed, about four feet wide, containing disseminated galena and iron pyrites. It appears in three places, ranging in the granite nearly north-west and south-east.

§ 101. On the south side of Glenmalur, indications of metals also occur. On Mr. Parnell's ground, is a vein of quartz, from one and a half to two feet wide, passing through granite and mica slate, ranging nearly parallel to the valley, and bearing the same minerals as the veins on the north side of the glen. The trials made upon this vein were not productive.

§ 102. A consideration of the tract, over which we have just now passed, suggests the reflection, that the powerful agent which moulded the glens and vallies, into their present form, appears to have operated subsequently to the production not only of the rocks themselves, but also of the veins by which they are traversed. This seems to be proved by the perfect parallelism, which subsists in the direction, and inclination, of the strata on the opposite sides of the vallies, and this appearance is uniform throughout the tract that we have proposed for consideration; and by the same veins pursuing their course without deviation across the vallies, and up steep precipices on the opposite sides, as exemplified in particular by the great vein at Glendalough, and by the vein in Carriggeenduff.

2. *Metalliferous Relations of the Clay Slate Tract.*

§ 103. The metallic substances found in this tract, are eleven in number; namely, gold, silver, copper, iron, lead, zinc, tin, tungsten, manganese, arsenic, and antimony.

§ 104. In the county of Wicklow, the metalliferous clay slate district occupies but a small space, being very narrow in breadth, and in length not more than ten miles, extending from Croghan Kinshela on the south, through the townlands of Knocknamohil and Ballymoneen, Ballymurtagh, Ballygahan, and Kilcashel, Cronebane and Tigrony, Kilmacow and Connery, toward the West Aston range on the north; (see Pl. 8. No. 7.)

§ 105. The discovery of native gold in the Ballinvalley stream at Croghan Kinshela was accidental, and at first kept secret; but being divulged, almost the whole population of the immediate neighbourhood flocked in to gather so rich an harvest, actually neglecting at the time the produce of their own fields. This happened about the autumn of the year 1796, when several hundreds of people might be seen daily assembled digging and searching for gold in the banks and bed of the stream. Considerable quantities were thus collected; this being, as it subsequently proved, the most productive spot; and the populace remained in undisturbed possession of the place for nearly six weeks, when Government determined to commence active operations. An Act of Parliament was then passed for the management of the undertaking, and Mr. Mills, Mr. King, and the author of this Memoir, were appointed Directors. Regular stream works were soon established, and up to the unhappy period of the rebellion in May, 1798, when the works were destroyed, Government had been fully reimbursed its advances; the produce of the undertaking having defrayed its own expenses, and left a surplus in hand. In the year 1801, the operations were resumed, when the Directors proposed to Government not to confine its views to the mere collection of the alluvial gold, but to extend the researches, directing them more particularly toward the discovery of auriferous veins. They were justified, as they conceived, in this proposition by the following considerations:

1. The well-known fact that in the various quarters of the world, in America, Africa, Asia, and Europe, auriferous veins often occur

in the mountains adjacent to the districts that abound in massy alluvial gold.*

2. The peculiar circumstances under which the native gold of Croghan Kinshela was found. It occurred in massy lumps, and in smaller pieces, down to the minutest grain. One piece weighed twenty-two ounces, another eighteen ounces, a third nine ounces, and a fourth seven ounces. The gold was found, accompanied by other metallic substances, dispersed through a kind of stratum composed of clay, sand, gravel, and fragments of rock, and covered by soil, which sometimes attained to a very considerable depth, from twenty to fifty feet, in the bed and banks of the different streams. By the operations in the stream works, (which are too well known to professed miners, to need detail on the present occasion) all the metallic particles thus disseminated were collected in a concentrated mass; and in those at Ballinvalley it was constantly found that the gold was attended by magnetic iron stone, sometimes in masses of half a hundred weight, by magnetic iron sand, by cubical and dodecahedral iron pyrites; and in small pieces and grains, by specular iron ore, brown and red ironstone, iron ochre, fragments of tinstone crystals, wolfram, grey ore of manganese, pieces of quartz and chlorite, and sometimes fragments of quartz crystals. I observed and collected also some specimens, which shew that the gold, magnetic ironstone, and wolfram, were each of them frequently intermingled with quartz; and I have also a few specimens, which exhibit the gold not only incorporated with iron ochre, but ramifying in slight threads through wolfram. Some of the gold, though

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* See, for example, the Travels of Ulloa and of Humboldt in America; Molina's Chili; Park's Travels in Africa; Marsden's Sumatra; Turner's Thibet; Abhandlungen über Bergbaukunde; Dr. Clarke's Travels in Europe, Asia, and Africa, vol. IV.; Robilant on Piedmont, in Journal des Mines, vol. IX.; and D'Aubuisson in vol. XXIX.

very rarely, occurred crystallized in octohedrons, and also in the elongated garnet dodecahedron, of which I retain specimens.

3. The ascertained fact that several of the contemporaneous veins of quartz, contained in the mountain, were metalliferous, yielding magnetic ironstone, iron pyrites, copper pyrites, blende and iron ochre, with chlorite, and quartz crystals.

Under these considerations, the measures proposed by the directors were: to continue the stream works, progressively advancing toward the head of the several streams; to examine more closely the solid mass of the mountain, by means of trenches to be cut in various directions down to the firm rock; to explore more fully the veins already known, and those which might be discovered near the surface by the trenches; and lastly, to try these veins, at a considerable depth from the surface, by means of a gallery or level, to be driven into the mountain, in a direction nearly at right angles with the general range of the veins, selecting that quarter where they appeared to be most numerous.

These measures, receiving the sanction of Government, they were carried into effect: and numerous trials were made by driving and sinking on the veins previously known, and subsequently discovered. The mineral substances obtained, were subjected to the operations both of fire and of amalgamation; but in no instance was a particle of gold elicited from them either by the one or the other process. So unsatisfactory a result led to the persuasion, that the gold formed no part of the veins which appear in the mountain; and hence Government were induced to abandon the enterprize.

The same conclusion seems to apply to the tinstone, wolfram, and manganese, in discovering which the mining operations equally failed. What is then the primary source of these substances, found detached in the beds and banks of the streams? It is not improbable that they occur more or less scattered and disseminated through the rocks of the mountain, although it must be acknowledged that no discovery leading to this inference attended the researches of Government. It is, however, well known, that such occurrences are not uncommon in other tracts;* and we may then conceive the gold, and the other metallic substances, to have been detached from their native seat, and to have been lodged in their present position, in company with other alluvial materials, at the time of the first formation of soil, upon the retrocession of the ocean.

The total quantity of native gold collected by Government amounted to 944 ounces, 4 pennyweights, and 15 grains, of which 58 oz. 16 dwts. 1 grain, were sold as specimens at 4l. per ounce, amounting in value to 236l. 10s. 8d. The remaining 885 oz. 8 dwts. 14 grains, I melted and cast into ingots, which weighed 848 oz. 18 dwts. 5 grs. Hence the loss in melting was 36 oz. 10 dwts. 9 grs., or nearly $4\frac{1}{4}$ per cent. which arose from disseminated particles of quartz. The ingots produced from $21\frac{3}{8}$ to $21\frac{7}{8}$ carats of fine gold, the alloy being silver; and they were bought by the Bank of Ireland at prices varying from 4l. 0s. 6d. per ounce, to 4l. 2s. per ounce, amounting in value to 3438l. 17s. $3\frac{1}{2}$d. Hence the aggregate value of the native and ingot gold was 3675l. 7s. $11\frac{1}{2}$d.

§ 106. The annexed map of Croghan Kinshela will tend to elucidate not only what has been said respecting its geological relations, (§ 63.) but also the nature of the operations which were carried on there; the whole being laid down from actual survey; (see Plate 11.)

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* See, for example, Ulloa's Travels in South America, vol. II. p. 160, English Translation; Humboldt's Political Essay on New Spain; Charpentier's Beobachtungen über die Lagerstätte der Erze; Von Buch's Geognostische Beobachtungen auf Reisen durch Deutschland und Italien, vol. I. p. 128—130.

The principal depot of the Ballinvalley gold extended about six hundred fathoms down the stream below the ford. In other quarters the gold obtained was comparatively of small amount. The largest piece found in any of the other streams was on the Coolbawn side. It weighed 2½ ounces. But in all these cases, the gold was accompanied by most of the metallic substances enumerated in the Ballinvalley stream.

By the Ballinvalley trench alone, twenty-seven veins of quartz were found, varying from nine inches to four feet wide, in a distance of 700 fathoms; and in the same manner, by the Ballinagore trench eighteen quartz veins were discovered, in a distance of 600 fathoms. These veins partly range and dip with the slaty rock, but they also ramify and terminate in strings which intersect the latter. They are evidently contemporaneous, and most of them are barren, but some were found bearing magnetic ironstone, iron pyrites, and iron ochre, with chlorite. Two of the most powerful veins occur on the western side of the northern arm of the mountain, one being six feet wide in the broadest part, and the other four feet. They consist principally of massive magnetic ironstone and quartz, with disseminated copper pyrites, and iron pyrites. A similar vein, four or five feet wide, with the addition of blende, occurs near the extremity of the northern arm, and another, two and a half feet wide, appears in the face of the rock over the Daragh river. Trials for copper ore were made on these veins in the course of the last century, but they proved unproductive, being found to consist almost exclusively of iron ore; and the same fate attended extensive superficial operations, conducted upon similar viens, in Knocknamohil and Ballymoneen, to the north of the Daragh.

§ 107. But the discovery of native gold was not confined to Croghan Kinshela. Trials were instituted by the directors in another mountain also, named Croghan Moira, (see Pl. 8. No. 7. and 10. No. 18.), about seven miles distant from the former mountain, and gold was obtained there, though in very small quantity, the largest piece not exceeding two and a half pennyweights in weight. One trial was made on Ballycreen in the stream at the eastern foot of the mountain, and minute particles of gold were found, accompanied by magnetic ironstone, magnetic iron sand, compact brown ironstone, cubical iron pyrites, and numerous small garnets. Another trial was made on the western side of the mountain, in Ballynacapogue brook, and small particles of gold were obtained, with magnetic ironstone, magnetic iron sand, and fragments of tinstone crystals. A third trial, in Fannanerin stream, on the north-eastern flank of the mountain did not produce any gold.

§ 108. It is remarkable that toward the middle of the last century, a brown indurated oxide of iron, which formed the upper part of a metalliferous bed in the higher grounds of Cronebane, was found to contain minutely disseminated native silver, sometimes in extremely slight filaments, but generally in particles quite imperceptible to the eye. The silver was extracted by fusion with lead, and subsequent cupellation. It contained about thirty grains of gold in the ounce, equivalent to 6¼ per cent. and hence, the auriferous silver commonly sold for half-a-guinea an ounce. Articles made from both the metals so extracted are in the possession of a family in the county. This oxide of iron appears to have borne a close analogy to the *pacos* of Peru, and the *colorados* of New Spain, as described by M. Von Humboldt.*

§ 109. The present Company of Cronebane commenced their operations in the year 1787, having purchased the mines and fee of that estate, and also part of Tigrony, upon their losing the lease of the celebrated Parys mine, in Anglesea, of which they were the original discoverers. In 1798, they were incorporated by act of Parliament, under the firm of The Associated Irish Mine Company; and as resident acting partner, I have for many years had the immediate direction of the operations. An opportunity was thence afforded me of obtaining a full insight into the mineral structure of this district, which I shall now describe.

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* See the Political Essay on New Spain.

Metallic substances are diffused through the whole territory, in disseminated particles, in slight layers, in contemporaneous veins and strings, and in massy beds, which last are principally composed of copper pyrites and iron pyrites. The rocks have been perforated in various directions by the subterranean works, the line of which, extending into Connery and Tigrony, occupies more than one thousand fathoms. The annexed plan and sections of these works will convey a general idea of their nature, (see Plate 12.); but being laid down on a very small scale, the underground excavations are mostly omitted in the plan, as they could not be introduced without producing confusion.

§ 110. The clay slate and quartzose clay slate (§. 62,) contain subordinate beds of what are technically termed *soft ground.* As far as explored, they vary from three to fourteen fathoms in width, and extend to an uncertain distance; but some have been traced for more than one hundred fathoms, while in depth they generally become more compact and firm. This soft ground, which requires timber for its support in the operations of miners, consists of tender decomposing clay slate, varying from a light yellow or grey to a deep black colour, abounding in pyritous particles, particularly of iron, but sometimes also of copper, and even of arsenic; and generally accompanied by a considerable body of greyish or yellowish white clay. When brought to the surface and exposed to the influence of the atmosphere, these substances undergo rapid decom position and enter into new combinations, forming sulphate of iron, sulphate of copper, alum, and oxide of iron. Similar combinations take place also below ground, where moisture and a circulation of air prevail through the subterranean workings; and water percolating through these, it becomes charged with the metallic salts.

In a bed of this soft ground are contained one or more layers parallel to each other of copper pyrites, or mere iron pyrites, varying in thickness, and sometimes acquiring a breadth of several fathoms. Five such beds of soft ground have been met with, one in Connery, two in the old or upper mine of Cronebane, one in the new or lower mine, and one in Tigrony. In the map of these mines, I have distinguished their several positions by a bluish grey colour; (see Plate 12.) That in Connery contains a bed of ore about four feet thick, consisting of a fine grained intermixture of galena, grey ore of antimony, and blende, with pyrites of copper, iron, and arsenic. These constitute together a very hard and firm compound; but as no one metal predominates in any considerable degree, the working of it has not been attended with advantage. A similar compound occurs in the second and more southern bed of the upper mine in Cronebane, being found in its north-eastern prolongation, where it is crossed by the Lodge Level. The more northern bed contains much iron pyrites, and it has yielded at different periods some thousand tons of black copper ore, which in the greater depths of the mine passes into copper pyrites. It was on the outcrop of this bed that the oxide of iron occurred, which yielded auriferous silver. The third bed in Cronebane, situated in the western flank of the hill, has proved the most valuable, the greater part of its width being occupied by copper ore, which in the upper part consisted principally of black ore, but at greater depths passed into copper pyrites, with iron pyrites. The bed of solid ore has varied from one to three fathoms in breadth, but thin parallel layers of ore are interstratified with the adjacent clay slate also to a certain distance. No quartz or spars of any kind attend these beds. The more productive parts of the bed have in several instances yielded from ten to fifteen tons of merchantable ore from the cubic fathom, the average produce of which has varied from five to seven per cent. of copper. In some parts of its course, this bed did not produce copper ore till nearly at the depth of forty fathoms from the surface, the upper part consisting principally of a brown indurated oxide of iron, in which I have sought in vain by repeated experiments for the auriferous silver, that had occurred in a similar oxide in the upper mine. The bed in Tigrony has yielded only iron pyrites.

§ 111. Beds of iron pyrites, from a few feet to some fathoms in thickness, have appeared also in the firm clay slate and quartzy clay slate; as in the deep levels in Tigrony and Cronebane. And thin layers and slight threads of copper pyrites and iron pyrites are very frequent. Galena and blende have also been met with under similar circumstances, but much more rarely; as well as casually disseminated in small portions in the beds of copper pyrites, and iron pyrites.

§ 112. Several contemporaneous veins of quartz bearing rich copper pyrites, accompanied sometimes even by earthy azure copper ore, and not unfrequently by chlorite, and whose average produce is ten to twelve per cent. of copper, also occur, and more particularly in the quartzy clay slate. These veins mostly range and dip with the clay slate, ramifying in their extremities through the rock; or sometimes coalescing again, they form a considerable body, even twelve feet wide of vein, and four or five feet wide of solid ore: but they seldom continue productive for more than thirty fathoms in length. There are several small ones of this description in the upper mine; and in the lower mine there are six in the vicinity of the Copse and Boundary shafts, and two in that of the Farmer's shaft. These have yielded considerable quantities of valuable ore.

§ 113. In the course of the operations attending the driving of levels and sinking of shafts in Cronebane and Tigrony, I have observed that the slaty rocks, (whose general range is nearly north-east and south-west, and dip south-east at an angle of 65°) are divided into great beds, commonly about five fathoms thick, by parallel seams or joints, which intersect the inclined plane of the clay slate at right angles, dipping 25° toward the north-west. These seams are open fissures, which sometimes will admit one or two fingers, and at other times scarcely the blade of a knife. In their progress they pass uninterruptedly through all the beds and contemporaneous veins included in the slaty rocks, dividing them, and sometimes producing, as it were, a sensible alteration in their disposition, though to no great extent. This tendency toward a division into horizontal beds, (independent of the slaty structure) may also be observed in several parts of this district, where the rock has been partly exposed to observation; as for instance, in the line of the new mail-coach road, in constructing which several rocks have been cut into at a great expense.

§ 114. In the twelve years, ending 1799, the mines of Cronebane had yielded 7533 tons of ore, which produced on an average $8\frac{25}{28}$ per cent. equal to 670 tons, 11 cwt. of copper: a duty of sixteen shillings and sixpence British per ton having existed up to this period on the importation of Irish ores into Great Britain.

In the next twelve years, ending 1811, the produce was 19,342 tons, 13 cwt. of ore, yielding $5\frac{5}{12}$ per cent. equal to 1046 tons, 10 cwt. 2 qrs. of copper. Hence, the aggregate produce from the commencement to that period was 26,875 tons, 13 cwt. of ore, average produce $6\frac{13}{33}$ per cent. equal to 1717 tons, 1 cwt. 2 qrs. of copper.

In the year 1808, the ore raised was 2576 tons, 14 cwt. At this period the produce of copper mines suffered a great depreciation in the market, from which it has not since recovered. Hence in the subsequent years, the ore raised at Cronebane has not exceeded a few hundred tons.

§ 115. The mineral waters flowing both from the upper and lower mines are impregnated with sulphate of copper. These waters are received into tanks, in which the muddy particles are allowed to subside. The clear waters are then passed into pits filled with plate and scrap iron, which causes a precipitation of the copper. In this manner 442 tons, 11 cwt. 3 qrs. of this precipitated copper (mixed with oxide of iron) have been obtained, which sold on an average for 27l. 8s. 9d. per ton, being in aggregate value 12,126l. 18s. 1½d. while the consumption of iron was only 429 tons, 14 cwt. or less than one ton of iron to the ton of precipitate, being in aggregate value 2620l. 18s. 8d.

§ 116. Sulphur was extracted on the spot from the copper pyrites, obtained from the mines, by the following process: the ore broken into fragments of the size of large walnuts, and freed from smaller particles, was placed in low cylindrical kilns with a flat bottom, capable of holding fifty or sixty tons of ore. On the opposite sides of the kiln were four apertures, and these were connected across the bottom of the kiln by open flues of bricks. On the flues was placed a layer of heath and furze; the kiln was then filled, and on the top of the ore was constructed a cross close flue, which led to an arched receiver sixty or seventy feet in length, four feet in breadth, and six feet high; the surface of the ore being covered close in all other parts. The kiln thus formed a retort upon a large scale. Firing was now placed in the apertures, and continued until the ore in the vicinity acquired a red heat, when the openings were stopped, and the process of sublimation, which commonly lasted six weeks, was left to go on spontaneously. When the work was well managed, a nucleus of rich yellow or grey sulphuret of copper, surrounded by brownish red oxide of iron, might be found in each piece of the burnt ore. In this state, the ore being steeped in water, a solution of sulphate of copper was obtained, and the copper precipitated by iron; and the kernels of the sulphuret, that remained without decomposition, were separated from the slimy oxide by washing.

The crude sulphur deposited in the receivers was refined and cast into cane or roll brimstone. In this state it sold during the war for between twenty and thirty pounds per ton.*

§ 117. On the south of the Ovoca, the structure is analogous to that on the north of that river; (see Pl. 8. No. 7.) In Ballygahan, considerable researches were made by the Cronebane Company, but without advantage. In Ballymurtagh, extensive works were carried on by Mr. Whalley during a part of the last century, and a large fortune was acquired; but later speculations have been unprofitable, although the old bottoms, which are about thirty fathoms deeper than the level of the river Ovoca, were freed from water. In Kilcashel, some trials have been made, and copper ore met with, but the estate has not been fully explored. Indications of copper in Avondale, and of lead in Knockanode, have also appeared, but only in the form of slight strings.

§ 118. At Came, in the county of Wexford, a lead mine was discovered and wrought a few years since. It was a contemporaneous vein of quartz, ranging and ramifying in clay slate, and bearing galena, white lead ore, blende, iron pyrites, and copper pyrites. Of the copper ore, twenty-four tons were shipped, and of the galena, it is said, a few hundred tons. The workings extended about thirty fathoms in length, and went down in the deepest part about twenty-four fathoms; but having no command of level, nor sufficient water to impel machinery, they were discontinued.

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* The fee and mines of Cronebane are now on sale.

II. *Transition Tracts.*

§ 119. In the whole field of our inquiry, I have not met with any rocks that possessed decidedly the character of transition formations, except on the coast of the county of Dublin. They appear there in detached portions, comprehending the islands adjacent to the shore; as at Portrane headland, a small patch at Loughshinny, and the coast extending from the south of Skerries past Balbriggan, to the Delvan stream on the north, which divides the county of Dublin from that of Meath.

§ 120. These transition tracts are mostly bounded by the floetz limestone formation; and as the rocks of both classes exhibit upon this coast relations deserving particular attention, I shall, in the proper place, enter into a full description of the portions occupied by them respectively. By following this plan, we shall obtain the advantage of tracing in uninterrupted succession the relations of the primary, transition, and floetz rocks, in immediate connexion with each other; and the survey of the coast of the county of Dublin will be completed. The remainder of the great limestone field may then be treated in a more general manner.

§ 121. The rocks of the transition class exposed to our observation upon this coast, are clay slate, clay slate conglomerate, greywacke, and greywacke slate, interstratified with limestone, limestone conglomerate, trap, and porphyry.

§ 122. Portrane* and Dunabate form nearly a peninsula, being flanked on the north and south by inlets from the sea. The former is the more considerable elevation of the two, being separated from the latter by an intervening hollow.

The eastern part of the headland of Portrane consists of transition rocks. In the south-eastern quarter, under Portrane house, the hollow, which winds toward Dunabate, is occupied by red sandstone conglomerate; and this rock appears to constitute the whole of the rising ground of Dunabate, at the foot of which the new chapel may be seen founded upon the sandstone. To the westward of Dunabate, the country consists of floetz limestone, and the western part of Portrane, on which the mansion stands, appears also to be composed in part of limestone; for, in sinking a well there seventy feet deep, fifty-nine feet passed through soil, and the last eleven feet were sunk in limestone; but this is probably connected with the transition rocks in the eastern quarter. The actual contact of the rocks here noticed cannot be traced, but from their general position I am led to infer that the sandstone conglomerate rests upon the transition series: and we shall now follow the latter in the line of their succession around Portrane headland.

The north side of this promontory exhibits rugged rocks composed of massy unstratified greenstone, which extend to the eastward about sixty yards beyond the quay. This greenstone is commonly a compact felspar coloured by hornblende, varying from a greyish green to a dark blackish green. Sometimes, however, it is reddish brown, or brick red, and in patches siskin green. In some places it acquires the characters of claystone; and in others, the rock consists of ill defined crystals of hornblende and felspar. Calcareous spar appears also, disseminated in spots, increasing occasionally so much as to constitute nearly the mass of the rock. Disseminated iron pyrites likewise occurs, and the greenstone is partly traversed by small contemporaneous veins of calcareous spar and quartz; and in two instances by veins composed of a mixture of epidote and quartz. The greenstone is also porphyritic in some places, as near the western side of the quay.

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* The seat of Geo. Evans, Esq. to whose friendly attentions I am much indebted in the examination of this coast.

Proceeding along the coast, we perceive at low water the massy greenstone presenting a face, which declines to the southward under an angle of 46°, and within a few feet of it is a stratified conglomerate in a similar position, which no doubt rests upon it; the line of range being 15° north of east and south of west. This conglomerate consists of a base of compact greenstone slate merging into clay slate, and involving rounded and angular fragments of limestone, greenstone, and calcareous spar, and also pebbles of a mixture of greenstone and calcareous spar, and of conglomerate, analogous in composition to that of the whole mass. Through the base a good deal of calcareous spar is disseminated, and sometimes also quartz. Some of the fragments are of the size of the head, and in general they affect a flattened form with rounded angles, but many of them appear as complete pebbles.

This conglomerate, or coarse greywacke, presents a rough aspect in the parts adjacent to the greenstone, but in proceeding to the south-eastward we observe it to acquire a finer grain, though occasionally intermixed with a coarser grained, and passing into greywacke slate. It is succeeded by beds which alternate with each other, from a few inches to six and eight inches thick, composed of coarse grained conglomerate, greenstone, and finer grained conglomerate, all analogous in composition to those already described. We now encounter a conglomerate, composed of angular and rounded masses of greenstone, cemented by calcareous spar; and this is succeeded by slaty fine grained conglomerate, into which it seems to pass. Limestone then appears, at first intermingled with greenstone and greywacke slate, and afterwards alternating with the latter rock. The range of the beds in this spot is north-east and south-west, and the dip 20° south-east. The intermixture of limestone with the greywacke slate is very distinct in the vertical section of the cliff, south of the martello tower; where we perceive numerous boulders, pebbles, and masses of limestone scattered through the rock, frequently affecting a nearly rectilinear disposition across the strata, and nearly at right angles with the dip; (see Plate 13. fig. 9.)

In a similar cliff, adjoining on the south, this arrangement is still more striking, the limestone pebbles appearing in clustered masses of an irregular form, and occupying a space from a few inches to five and six feet wide, but also affecting a disposition at right angles with the dip of the greywacke slate; (see Plate 13. fig. 10.)

In a cave, a little farther south, the limestone is seen in thin layers seldom exceeding four or five inches in thickness, repeatedly alternating with the greywacke slate. The range is here 10° west of north and east of south, and the dip 50° toward the east. Farther south, the alternating beds of limestone gradually acquire a greater thickness, but even here some of the beds consist of conglomerate, composed of large pebbles and angular fragments of limestone cemented by greywacke slate. Limestone now predominates in massy strata, some of which are several feet in thickness, ranging

20° east of north and west of south, and dipping 50° toward the east.

On these massy strata are incumbent alternating beds of limestone and greywacke slate, some beds of the former substance being even four, five, and six feet thick. These rocks are much contorted; and indeed inflections prevail throughout the eastern part of this coast, from whence arise the various range and dip already observed. In this quarter, the deeper beds lie almost horizontally, while the superior gradually acquire the high angle of 50°.

In a cove to the south, a conglomerate appears, the base of which is a mixture of clay slate and limestone, enveloping pebbles and even boulders, (two and three feet in diameter,) of limestone and of coarse greywacke, which consists of a clay slate base containing much limestone, calcareous spar, quartz, clay slate, and greywacke itself.

In the southern part of this cove, the limestone is seen supporting massy strata of fine grained greywacke four and five feet thick, and forming cliffs forty and fifty feet in height; but some of the strata are only a few inches, or one or two feet thick. The line of junction is well marked by a thin seam of calcareous spar, rising from the south to the north under an angle of 15°. In the lower strata, the greywacke is a firm compact rock, of fine grain, containing numerous small scales of silvery mica dispersed in all directions, sometimes also disseminated iron pyrites, and occasionally small fragments of clay slate. In the upper strata, it merges into greywacke slate, and into clay slate. These slaty rocks frequently alternate with thin layers of limestone, from one inch to $\frac{1}{8}$ or $\frac{1}{10}$ of an inch in thickness; and they are also traversed by numerous small contemporaneous veins and strings of calcareous spar and quartz.

The diffusion of calcareous matter is so general through the greywacke, greenstone, and slaty rocks of this coast, that few varieties can be found which do not effervesce with acids, even when nothing calcareous is visible to the eye.

Rocks of this description, greywacke slate and clay slate with thin layers of limestone, and fine grained greywacke with massy beds of limestone and limestone conglomerate, now occupy the coast for a considerable distance to the southward in undulated stratification; the slaty rocks forming the predominant superincumbent mass, while the general range is nearly east and west throughout.

Compact greenstone now appears, near the southern martello tower; some of which is porphyritic, and traversed by numerous contemporaneous veins of quartz. It is succeeded by fine grained greenstone slate passing into clay slate, which contains fragments and spots of clay slate, quartz, and calcareous spar. This rock rests upon the compact greenstone, ranging east and west, and dipping 45° south. More south we meet with compact greenstone again, resting upon the greenstone slate. It is porphyritic, and about 100 yards from the martello tower it consists entirely of greenstone porphyry, in which the felspar crystals are closely crowded together. But immediately under the tower we have greenstone slate again, similar to that before described. It seems nearly allied to the coarse clay slate or greenstone conglomerate, into which it probably passes; is of a mottled aspect, greenish or purplish in colour, and of this description is the whole rock south-east of the martello tower to the sea.

To the south of the martello tower, the beach is lined with sand hillocks, which extend to the inlet from the sea, that leads up to Malahide.

§ 123. In the higher grounds of Portrane, as in the Park and toward the house, we perceive only rocks of an analogous description, the general range of which appears to be nearly east and west, agreeing with that on the coast, although in some places inflected. The prevailing dip is to the south, varying from 50° to an almost horizontal position, being also in some parts inflected.

The limestone on this coast is bluish grey and even blackish grey, and of a varying texture, compact, partly foliated, and even nearly granularly foliated. In its fracture it exhibits no distinct petrifactions, yet when examined below the line where it has been acted upon by the sea, organic remains are displayed in the most marked manner, protruding above the surface of the wasted stone. They consist principally of zoophytes, with some bivalves. In the conglomerate rock under the pigeon-house in the Park, (the base of which is a mixture of limestone and greenstone enveloping pebbles of limestone and greenstone), bivalves, entrochites, and madreporites may be observed.

I have frequently remarked that the same secondary limestone, which on the fresh fracture exhibited no appearance of organic remains, after exposure to the influence of the atmosphere for a length of time, became partially wasted, leaving a surface studded with petrifactions.

§ 124. In the isle of Lambay, the upper grounds are studded with rocky knolls, while on the brows, projecting crags are also observable here and there; but along the coast, which on the south, the east, and the north, is abrupt and precipitous, the cliffs afford opportunity for examining the component rocks. The western side also, though depressed and flat in comparison, presents the same advantage, a low ledge of rocks lining the banks, and craggy prominences protruding above the beach; (see Plate 8. No. 9. and 9. No. 13.)

This island is principally composed of trap rocks; massy unstratified thick beds of compact greenstone and greenstone porphyry, perfectly analogous, in composition and aspect, to the same rocks in Portrane headland. These beds include, and are interstratified with smaller beds of stratified rocks, composed of clay slate, clay slate conglomerate, greywacke, and greywacke slate, in alternation with each other. The trap and the slaty beds thus constitute seven or eight alternations on the large scale, the prevailing range of which is 20° north of west and south of east, with a dip of 65° toward the west of south; and in one instance they appear to be intersected by a powerful vein, or dyke, of sandstone conglomerate.

From the Great Bay on the north side of the island to Seal-hole Bay on the south side of the eastern headland, the whole coast presents rugged mural precipices of greenstone and greenstone porphyry, which exhibit only occasionally a disposition toward a rude stratification, with a dip toward the west of south. The porphyry is visible in many parts of this island, but no where in greater beauty than in the eastern headland, where the compact greenstone is thickly sown with crystals of compact felspar, of a yellowish white, greenish grey, or pale siskin green colour. To the south-westward of this porphyry, the rock merges into amygdaloidal greenstone; having a base of light greyish green compact felspar, closely crowded with kernels and small round grains of chalcedony, quartz, and calcareous spar; which being sometimes removed by decomposition, leave empty cavities, but in general they are completely occupied. Toward the south-west, the amygdaloid graduates again into compact greenstone, and this latter rock, on approaching a body of clay slate conglomerate in Seal-hole Bay, acquires a fissile texture, and passes into greenstone slate, and ultimately into clay slate. The clay slate conglomerate constitutes a bed at least 200 fathoms in thickness, ranging 20° north of west and south of east, and dipping 65° toward the west of south. In its line of apposition to the compact greenstone on the north, it occupies only a small part of the northern side of Seal-hole Bay, but it also lines the bay itself, and extends to its south-eastern angle. This bay seems in fact to owe its form to the inroad of the ocean upon the great bed of conglomerate, the materials of which it is composed being loosened and disjoined by the action of the sea and the atmosphere. At the bottom of the bay a cavern has been formed, about thirty yards in length, which is frequented by seals, of which three or four have been taken there at a time. The conglomerate there forms high impending cliffs; and in its structure it is analogous to the clay slate conglomerate which rests upon the massy greenstone to the east of Portrane quay: a base of clay slate enveloping rounded and angular pieces of limestone, compact greenstone, fine grained greywacke, and greywacke slate, with some quartz, and calcareous spar being also more or less diffused through the mass. Some of the rounded and angular fragments exceed twice or thrice the size of the head. In the limestone fragments, organic remains, as bivalves, and also some entrochites, may frequently be observed.

The clay slate conglomerate is succeeded to the south-west by massy compact greenstone with little, or no distinct, appearance of a subdivision into strata; and this rock constitutes the precipices along the south-eastern angle of the island, until we enter a deep bay on the southern side, which is to the east of Talbot bay. Here may be observed two beds of clay slate imbedded in the massy greenstone, one in the eastern, the other in the western quarter; but neither of great dimensions. The range and dip seem conformable to what has been already stated. In Talbot bay is a third bed, which nearly occupies the inlet, forming the middle and part of the sides, being flanked on either hand by greenstone. This bed is about sixty yards wide, and in the eastern quarter it consists principally of clay slate, frequently traversed by small veins and filaments of calcareous spar. This rock sometimes contains also small imbedded portions of limestone and pebbles of differently coloured slate, and it merges into greywacke slate, being interstratified in thin beds with fine grained greywacke. In the western quarter, these rocks are joined by, and in immediate contact with a perfect clay slate conglomerate, in which the fragments are not in general much larger than walnuts or hazel nuts, but some of them are nearly as great as the head. This coarse clay slate conglomerate is succeeded on the west by a similar rock of finer grain, or by greywacke, and greywacke slate, but to the west of this we find a fine grained greenstone conglomerate. These latter rocks form massy strata, four or five feet thick. There is an evident affinity and intermixture between the greenstone conglomerate and fine grained greywacke, so that in some places these rocks partly interchange characters. All these beds range 20° north of west and south of east, and dip 65° toward the west of south.

The greenstone conglomerate merges, toward the west, into compact greenstone, containing nodules or nuts of calcareous spar; and hence near the surface, this rock has in some places a vesicular aspect, from the decomposition of the carbonate of lime. It passes into greenstone, nearly compact, and this into greenstone porphyry. Farther west we encounter another, but smaller, bed of clay slate in an inlet from the sea, which is succeeded by compact greenstone: and in the last inlet to the west which occurs on the south side of the island, we find another bed of clay slate, accompanied by clay slate conglomerate similar to that occurring in the western part of Talbot bay. It is succeeded by compact greenstone. These rocks range 30° west of north and east of south, and dip toward the north of east, a disposition probably arising from inflection.

In proceeding along the western shore of the island toward the north, compact greenstone alone appears, until on approaching the middle of the greater bay on this side, we meet with a body of greenstone conglomerate of uncertain width. It is followed by compact greenstone, which extends into the lesser bay, situated more to the north, where greenstone conglomerate re-appears, and is succeeded by clay slate, which contains numerous small contemporaneous veins and strings of calcareous spar, and also intermingled portions of the same substance. This bed ranges 20° north of east and south of west, and dips 45° to the east of south, passing in its course through the north-western angle of the island, and re-appearing in the western part of the Great Bay on the north side. It rests upon, and is succeeded to the north-west by compact greenstone full of veins, strings, and contemporaneous masses of calcareous spar, and forming the eastern side of a small cove or inlet, in which interesting relations are displayed. We here find, to the north of the greenstone, a body of stratified sandstone conglomerate, ranging 20° north of west and south of east, and dipping 50° toward the east of north. On the other side of the sandstone conglomerate, we have clay slate again, which ranges like the preceding bed of clay slate, or 20° north of east and south of west, with a dip of 45° toward the east of south. Beyond the clay slate, greenstone re-appears, extending to the extremity of the island in that direction. These rocks are also visible on the western side of the north-western angle, in which the same arrangement is to be observed; but from the lowness of the coast on this side, the sandstone conglomerate is often concealed by the shifting of the gravel on the beach.

The clay slate, on the north side of the sandstone conglomerate, forms a bed about five fathoms in width, containing numerous veins and strings of calcareous spar. This conglomerate constitutes a body about fifteen fathoms in thickness, subdivided into strata from one to four and a half feet thick. Excellent millstone might be raised here, were not the situation so much exposed to the assaults of the sea. The two kinds of rock are sensibly affected by their proximity to each other; the conglomerate appearing in the form of a more or less coherent gravel and sand, of a deep red colour, for five or six yards in width, and the clay slate, where in contact with it being decomposed for about the same extent. The greenstone on the south side of the sandstone conglomerate is similarly affected, and worn away, but the strata of conglomerate stand firm, and form a small promontory, projecting eastward into the sea. On the north side these strata are laid bare by the sea for about 200 yards in length, being fifty feet high in the highest point, and presenting an inclined face in that direction.

This sandstone conglomerate consists of pebbles and angular fragments of reddish brown iron shot quartz and white quartz, with smaller similar particles, agglutinated by a siliceous cement and a minute portion of reddish brown iron-shot sandy clay, constituting a hard, firm, and coherent rock. The reddish brown quartz sometimes approaches to the nature of iron flint. In the rock itself may also sometimes be observed disseminated portions of lamellar heavy spar.

From the preceding description, it is evident that a considerable degree of analogy subsists between the transition rocks of Lambay and those of Portrane, with the additional interesting appearance of a stratified vein of sandstone conglomerate intersecting the former.

§ 125. The coast on the south side of the Delvan stream, which borders the county of Dublin, exhibits rocks, composed of vertical beds of fine grained greywacke, greywacke slate, and clay slate, in alternation with each other, similar to those which line a part of the eastern coast of Portrane. They range 20° south of east and north of west, and thin layers of calcareous spar, and contemporaneous veins of the same substance, are not unfrequent in these rocks.

Following the coast, at low water, to the southward, repeated alternations of compact greenstone and clay slate appear; at first on the large scale, the beds of the former rock predominating in width and frequency. These are succeeded by similar alternations, from two to three fathoms in thickness, and these again by others, from a few inches to two and three feet thick. These rocks range mostly north-east and south-west, dipping 53° to the south-east. The clay slate contains in several places thin layers of calcareous spar. The greenstone abounds more or less in nuts, points, and contemporaneous veins of calcareous spar, the last being sometimes more than two or three inches wide. This rock exhibits also at times numerous scales of silvery mica; and sometimes it acquires a slaty structure and passes into clay slate.

From hence to the rock on the western side of the quay at Balbriggan, we meet in succession with compact greenstone, granular greenstone, or with greenstone passing into compact felspar, which acquires a slaty structure, much resembling some kinds of flinty slate. It ranges 20° east of north and west of south, and dips 30° toward the east. The rock at the quay is massy compact greenstone.

§ 126. In following the coast from Balbriggan to Skerries, we observe a cove to the south of the pier, the banks of which are occupied by alluvial soil and calcareous tuff; but in the projecting headland beyond, massy greenstone strata, three, four, and five feet thick, appear, ranging 30° north of east and south of west, and dipping 30° toward the south-east. These are succeeded on the south side of the headland by alternations of greenstone, (much mixed with calcareous matter,) and slaty greenstone passing into clay slate, followed by repeated alternations of fine grained greywacke, with clay slate and greywacke slate, lining the coast as far as the town of Skerries. Some of the slaty rocks vary in colour from pale bluish grey to deep bluish black, and finely disseminated iron pyrites is common in the greenstone and greywacke, both to the north and south of Balbriggan.

In these alternations, sometimes the greywacke beds predominate and sometimes the slaty beds, varying from a few inches to five feet thick. To the south of the greenstone promontory, they range for a considerable distance pretty regularly east and west, dipping 57° south. Subsequently, they range 25° south of east and north of west, dipping 35° to 40° toward the west of south, but on approaching the projecting ledge of loose blocks, called the *Long Leg*, they become singularly inflected and contorted, and the surface of the rocks having been broken away, they much resemble in aspect the agitated waves of the ocean. But they subside ultimately into a more regular arrangement, gradually rising to the south-westward, under an angle of 15°, and retaining that position for a considerable distance in parallel order, the greywacke beds, which predominate, being separated by thinner beds of slate. These rocks form the north side of a cove, the banks of which are composed of alluvial soil, but they re-appear in the eastern point, ranging north-west and south-east, and dipping 10° to 15° toward the north-east. Beds of this description, but in many places much contorted, line the beach, until on approaching the town of Skerries they acquire a range of 15° south of east and north of west, dipping toward the north-east. They now gradually rise to the vertical position, and at last acquire an opposite inclination, the south-west. From hence the beach exhibits only sand; but on the southern and eastern sides of the peninsula of Skerries, similar rocks are laid bare, ranging east and west, and dipping 30° south.

§ 127. From the different bearings observed in the direction of the beds on the coast, between the Delvan stream and Skerries, it is evident that they suffer several great inflections or curvatures, besides those which they display on the smaller scale.

§ 128. The stratified rocks which occur between the greenstone headland on the north, and the cove beyond the Long Leg on the south, abound in layers and contemporaneous veins and strings of calcareous spar and quartz, both of which substances enter largely into the composition of the fine grained greywacke, conjointly with clay slate, minute scales of silvery mica, and frequent finely disseminated particles of iron pyrites. The layers vary from less than one inch to twelve inches in thickness; the veins seldom exceed two or three inches in width; but both the calcareous spar and quartz occur either singly, or intermixed in these veins and layers. The appearances of some of these are very instructive, and tend to illustrate the doctrine of contemporaneous formation. The broken state of the coast exhibits frequent sections, both vertical and horizontal, in which these relations may be studied; and the same vein may frequently be followed with the eye to its termination, both in the horizontal and vertical direction. In the annexed sketches copied from nature, on this part of the coast, Plate 13. fig. 6.

represents a portion about six feet long by four and a half feet wide, of a firm bed of greywacke; the former dimension being in the line of the range, and the latter of the dip. The veins *a* and *b* are of quartz, mostly of a nearly pure white colour, but some of the veins of *a* are partly spotted pale bluish grey. The veins 1, 2, and 3, are white spotted with pale bluish grey, and these veins consist partly of grey quartz, and partly of white calcareous spar, to which the two colours are chiefly to be ascribed ; but the grey seems partly to arise also from minutely disseminated galena and brown blende, both of which substances I have discovered in these veins, though in very minute and scarce portions. The broadest of the veins do not exceed two or three inches. Plate 13. fig. 7. represents a contemporaneous vein of quartz in a fragment of greywacke, two feet long by one foot broad. It is an horizontal section. Plate 13. fig. 8. is a vertical section of the firm rock, fifteen feet long by six to seven feet high, exhibiting contemporaneous veins of quartz in greywacke.

In contemplating these subjects, I think it scarcely possible to avoid the conclusion, that contemporaneous veins have originated in fissures, consequent to the first stages of consolidation of the rocks in which they occur, and filled up by expression and infiltration from the consolidating mass. The facts, considered as supports to this opinion, are, 1st, the analogy of composition between the veins and the contiguous rock ; 2nd, the adhesion to and incorporation of the veins with the rock itself ; and 3rd, the intersection of the veins by the seams which also traverse the rock. We may likewise remark, that the seams sometimes heave or dislocate the veins, and that these seams are sometimes empty, sometimes occupied by quartz or calcareous spar.

The laws by which the operations of nature are governed are the same, whether exhibited in miniature or displayed on the great scale; and here, within the compass of a few square feet may be learned some of those principles, which alone yield a safe conduct to the miner in his subterranean researches; (§ 113.)

In the coast, extending from the cove above mentioned, to Skerries, veins and seams of quartz appear almost exclusively in the stratified rocks, those of calcareous spar having ceased to occur.

§ 129. The island of St. Patrick exhibits rocks of the same character as those of Skerries, composed of fine grained greywacke in alternation with greywacke slate and clay slate, in beds from half an inch to some feet in width, which preserve a due east and west rectilinear course throughout the island. The dip is uniformly toward the south, but the angle varies, approaching in the central part within 20° or 10° of the perpendicular, but to the southward acquiring the low angle of 30° with the horizon. In some of the slaty rocks may be observed thin layers of limestone from one-eighth to one-tenth of an inch in thickness, and also filamentous veins of the same substance. The western side of this island presents a good vertical and horizontal section of these rocks, in which the alternating beds are well marked by their difference of colour. They are sometimes waved on a very small scale, but the general direction remains nearly rectilinear.

§ 130. The constitution of the islands of Count and Shenex is similar; and as Rockabill islands lie nearly due east of these, it is highly probable that their structure is also the same.

§ 131. The transition district, which we have now followed from the Delvan stream to the parallel of Skerries, forms a narrow ridge inland, being immediately flanked on the west and the south by the floetz limestone formation; which appears also on the east, at low water, and covering the transition rocks at the point of

Knockbuye, to the south of Long Leg. It was here formerly quarried, but a few square perches only are now visible, being elevated two or three feet above the surface of the sea at ebb tide. To the north, the transition rocks appear to follow the coast to the mouth of the Boyne, and still farther north they probably abut upon the clay slate and greywacke hills of Louth, Meath, and Cavan; in which quarter, we may perceive three basins of floetz limestone reposing on the slaty rocks, one in the vicinity of Drogheda, another in that of Ardee, and a third, of greater extent, surrounding Carrickmacross.

§ 132. Loughshinny copper mine appears to have been conducted in transition rocks of narrow extent, denuded of the floetz limestone on the northern and eastern sides, but surrounded and covered by the latter formation in every other quarter. In the old hillocks we may observe fine grained greywacke, clay slate, and greywacke slate, and some fine granular greenstone; these rocks appearing there to bear a close analogy to those which occur on the coast south of Balbriggan. The ore was of a rich quality, but apparently derived from contemporaneous veins of quartz of uncertain extent. In the bank on the coast below, clay slate appears supporting the floetz limestone formation, but it is sometimes concealed by the shifting of the shingle on the beach.

III. *Floetz Tracts.*

§ 133. These comprehend old or first floetz sandstone, the floetz limestone formation, and the coal districts.

1. *First Floetz Sandstone.*

§. 134. This rock, within the tracts now under consideration, is found resting upon granite, upon clay slate, greywacke, and greywacke slate, and upon transition rocks. It occurs either in unconnected isolated portions, or in extensive mountain masses.

§ 135. The red sandstone conglomerate of Dunabate has been already adverted to (§ 122), where it appears to be in immediate contact with transition rocks. Its composition is the same as that of the great dyke in Lambay. A perfectly similar rock occurs in situ at the northern foot of the hill of Lyons (§ 54), where it is exposed for about ten fathoms in length, in strata four feet thick, ranging east and west, dipping 32° to the north, and resting unconformably on greywacke slate, some of its pebbles being as large as half the head. The strata no doubt underlie toward the north the floetz limestone, which occurs in the vicinity, and which also dips to the north 30°, as may be seen on the road toward Hazlehatch.

§ 136. Blocks and debris of the red sandstone conglomerate are to be observed scattered about this district. In the river Dodder, at the outlet from Glenismaule, is a block of this rock, seven feet long, by six feet broad and deep. Smaller detached portions are found also in the valley of the Dodder, and on the brows of the adjacent hills, and generally in the course of that river. They are strewed over the Tallow hills, and the Rathcool chain of hills, both on the higher grounds and on the flanks, and may be occasionally observed to the southward as far as the clay slate and greywacke country extends, on the western side of the granite region. I have incidentally also met with smaller fragments of the same rock on the eastern side of this mountain district, in the line of the Glencree, Glencullen, and Dargle rivers, on the banks and some way up the declivities of the adjoining mountains; but no farther in the interior on the eastern side, until we approach the southern part of the county of Wexford.

§ 137. This red sandstone conglomerate re-appears in the range of hills near the town of Kildare; (see Plate 6. No. 1.) Red hill, Dunmurry hill, and the western foot of Grange hill, consist of alternating beds of fine grained greywacke, greywacke slate, and clay slate, ranging 10° north of east and south of west, and dipping 60° toward the south-east, but in many places being nearly vertical. At the northern foot of Red hill, is a small patch of red sandstone conglomerate, which was quarried for millstone about a century since. At present little of the firm rock is exposed to view, but enough is visible, at the well, to show that the strata range east and west and dip 17° north.

The Chair of Kildare consists of floetz limestone, extending southward to the northern foot of Dunmurry hill, and apparently covering in this quarter the greywacke and slaty rocks. To the north it rests on the trap of Grange hill, which also appears to cover greywacke and slaty rocks. The hill of Allen is separated from Grange hill by an intervening vale, their summits being about two miles apart. The former is wholly composed of trap; but whether a distinct mass, or connected with that of Grange hill, is not easily ascertained from the depth of alluvial soil. At the northern extremity of the hill of Allen, about one quarter of a mile distant, is a slight eminence, called the Leap of Allen, composed of red sandstone conglomerate, arranged in beds which vary from nine to eighteen inches, and even to two feet six inches thick, and are separated by thin layers of reddish sandy slate clay. This contains the same components as the conglomerate already noticed, with the addition of fragments of greywacke slate, which are however comparatively rare. It is quarried for mill stones, the best of which sell on the spot for seven guineas and a half the pair. The beds range north-north east and south-south west, dipping south-south east, at an angle of 15° to 20°; and hence they probably underlie and support the trap of the hill of Allen. We shall have occasion hereafter, in the course of this paper, to return to the limestone of the Chair of Kildare, and to the trap of these hills.

§ 138. The Slieve Bloom mountains (see Plate 6. No. 2. and 7. No. 3.) consist of a nucleus of clay slate surrounded by sandstone. Pure clay slate is found here, but it is also frequently of a quartzy nature, graduating into flinty slate, and sometimes it shews a tendency toward the character of fine grained greywacke. These rocks range nearly east and west, or between 20° south of east and 15° north of west, dipping 70° toward the south. The sandstone appears to sweep round the clay slate nucleus, following the sinuosities, and curvatures formed by its surface, with a dip that conforms to the declivity. Quarries are formed all round the mountains, in some of which the strata are from one to three feet in thickness; while in others excellent flags are raised from an inch to four or five inches thick, and seven and eight feet square.

The sandstone of the Slieve Bloom hills seldom assumes the conglomerate character, and, as seldom, acquires the deep red cast, so characteristic in general of that rock. It is commonly yellowish white, or grey, composed of granular particles of quartz, closely aggregated; but it sometimes exhibits small porous interstices filled with yellow iron ochre.

§. 139. Sandstone in mass, extends from hence considerably to the southward, beyond Roscrea and the Devil's Bit mountain, often appearing in the form of conglomerate; (see Plate 7. No. 3. and 4.) The Bilboa and Keeper mountains likewise are surrounded by a mantle of sandstone, except in a small portion on the north side, to the south and east of the village of Silvermines; where, toward the foot of the hills, the clay slate nucleus comes immediately in contact with and supports the floetz limestone. The direction of the strata in this tract of clay slate appears to vary in different quarters. On the north side, they usually range north-north east and south-south west, dipping south-south east; in this part, however, they seem in some cases to dip on the declivity north-north west; but this is probably no more than a superficial inflection. In the western portion of the tract, in the vicinity of Lackamore mine, the range is north-east and south-west, and the dip south-east; but in a cross-cut driven from the mine to the north-west, the rock near the forebreast dips to the north-west. In the outlet of the Bilboa river on the south, the structure and succession of the rocks may be distinctly traced, the river being there confined to a narrow rocky channel, leaving lofty banks and brows on either side, near one hundred feet in height. Below the fork of the river the clay slate, which alternates with beds of the character of greywacke, supports sandstone conglomerate of a coarse structure in a conformable position, dipping at an angle of 20° to the north of west. The latter rock consists of a base of quartzy sandstone, enveloping numerous fragments of clay slate and quartz, of various size, and both rounded and angular, some of them exceeding the head in magnitude. But the upper strata of this conglomerate pass gradually into a fine sandstone, consisting of a minute granular aggregation of quartz, with scales of mica, and interstices filled with yellow iron ochre. From the fork of the river to the mouth of the defile, where the Bilboa discharges itself into the plain, is about three quarters of a mile. The sandstone disappears about one quarter of a mile below the fork under alluvial soil, the banks of which are here from 60 to 70 feet high. From the mouth of the defile to Castleguard is about one mile, and at this place floetz limestone crops out in massy strata, very close to the Bilboa river, dipping toward the same quarter as the sandstone, at first under an angle of 20° and subsequently of 10°.

That portion of the sandstone, which extends between Lackamore on the east and Newport on the west, is a red coarse conglomerate, very similar to the rock of Lyons and Dunabate. The best millstones are sold here for ten guineas the pair. In this part, the sandstone rests unconformably on clay slate, and toward Silvermines the latter rock may occasionally be found supporting the former in isolated portions. In the eastern quarter of this chain, the sandstone occurs both of a coarse and fine grain.

§. 140. This clay slate nucleus has yielded lead, silver, and copper. To the south of Kilboy, the seat of Lord Dunally, and of the village of Silvermines, extensive superficial works were carried on during part of the last century, between the townland of Knockenroe on the east and Gurteenadya on the west. They were resumed in Gurteenadya in 1801, but in 1807, when I visited them, the operations were not attended with success. The field of enterprize was of a peculiar character. Let us figure to ourselves an open space, formed in the line of the apposition of the limestone upon the clay slate, and probably produced by the subsidence and parting of the former from the latter rock on the declivity. This space is several fathoms wide at the surface, but it contracts in descending, and finally closes at the depth of about twenty-five fathoms. It was filled with clay, sandy clay, sand, decomposed slate, and scattered blocks of limestone, lydian stone, and sandstone; the whole mass being more or less cemented or penetrated by metallic depositions, consisting of iron ochre in various stages of induration, iron pyrites, white lead ore, galena, malachite, copper pyrites, and blende, with calcareous spar and heavy spar. In this *softness*, (as it is locally termed by the miner,) the old adventurers conducted their operations, and obtained, it is said, considerable quantities of lead rich in silver: acicularly crystallized white lead ore having been particularly abundant.

It is remarkable that in the clay slate tract immediately to the south of this line of *softness*, are several metalliferous veins, which do not appear ever to have undergone adequate trial. In Knockenroe especially, is a powerful vein, consisting at the surface principally of quartz and iron pyrites, with some heavy spar, galena, and blende. This vein ranges 15° north of east and south of west, and it may be traced a considerable distance through Ballino into Knockeen, ascending the northern brow of the hill, but disappearing below the sandstone, which covers the clay slate in the western quarter. In the latter part of its course, it exhibits also copper pyrites. And in Knockeen higher up, above the junction of the sandstone and clay slate, three other veins appear, ranging in the clay slate nearly parallel to each other, but of less dimensions than the one last mentioned, being only from two to three feet wide. These veins consist also of quartz, heavy spar, galena, blende, and pyrites.

§. 141. Lackamore copper mine is situated about five miles to the east of Newport, in clay slate, but so low in the valley that an adit level of twelve fathoms in depth is all that could be obtained. Here are two veins composed of brown spar, calcareous spar, clay, and iron ochre more or less indurated, a few inches in width; and a third vein composed of the same materials, but of greater thickness, bearing rich copper ore in bunches. The workings on this vein extended 120 fathoms in length, and 26 fathoms in depth, while an engine shaft was sunk 36 fathoms deep: and an attempt was made to renew them in the beginning of this century, but the machinery employed was insufficient to free the mine from water.

§. 142. The tract adjacent to the lower part of Lough Derg, (see Plate 7. No. 4.) consists partly of clay slate, and partly of old sandstone. The slate yielded by the quarries of Killaloe, in this vicinity, is not inferior to that of North Wales.

§ 143. The noble range of the Gaultees mountains, and its subordinate and lower ridge on the north-western side, called Slievenamuck, appear to consist wholly of sandstone. The north-western face of the Gaultees is in many parts extremely precipitous, and even inaccessible; the south-eastern partakes of a tamer character; (see Plate 7. No. 5.)

In this picturesque group, the strata of sandstone crop out in several places in the course of the range, being in the upper regions almost horizontal, yet gently curved; while on the flanks, where not abrupted, they appear to acquire a more rapid inclination, conforming probably to the shape of the surface of the clay slate which seems to constitute a base to the sandstone. We may distinctly mark a disposition of this kind in the northern portion of the Gaultees. In the lower part of a ravine on the south-eastern flank, above Caher, the rock has been quarried. It there exhibits strata of sandstone conglomerate, dipping at an angle of 70° toward the south-east, and consisting of quartzy sandstone, enveloping large and small fragments of green clay slate. Higher up, the rock is again displayed near the ravine, in strata from one to two feet thick, but dipping 15° toward the south-west, and on the opposite side of the ravine it re-appears under a similar arrangement, but lying rather flatter. The sandstone in these places varies much in character. In general it is a fine grained rock, composed of grains of quartz closely aggregated, but it sometimes contains interstices filled with iron ochre. It appears also as a perfect quartzy sandstone: and is sometimes quite red, composed of grains of quartz cemented by iron-shot clay, and frequently containing minute scales of silvery mica. All these varieties occasionally present also the character of sandstone conglomerate, exhibiting large rounded and angular pieces of white and reddish iron-shot quartz, and smaller portions of greenish clay slate. At the top of the mountain, the strata, which are from one to two feet thick, are gently curved or arched, following the form of the summit. Contemporaneous veins, and even masses, of quartz are here frequent in the whiter and granular quartzy sandstone; and thin parallel layers of sandstone conglomerate may be observed in the finer sandstone.

The sandstone of Slievenamuck appears to be arranged in horizontal strata, some of which yield excellent flags.

§ 144. The mountainous and hilly tract between the Suire and the Blackwater, (see Plate 7. No. 6.) extending from the county of Waterford into the counties of Tipperary and Cork, may be generally described as a table land of clay slate, partly bordered on the flanks by sandstone, and on the higher grounds sustaining isolated caps of the same rock, or upholding more widely extended, continuous mountain masses. The position of the sandstone borders generally follows the inclination presented by the surface of the subjacent rock, but the masses on the higher grounds approach more and more toward the horizontal arrangement, as they ascend. We find this disposition uniform, whether we penetrate through these mountains from the northern or the southern side, from Carrick, Clonmell, and Clogheen, or from Kilmacthomas, Dungarvan, Lismore, and Fermoy. This tract is surrounded by floetz limestone on the north, the west, and the south.

A border of sandstone approaches close to the Suire on the southern side, from the west of Clonmell to within five or six miles of Waterford; with two exceptions, in which a small patch of limestone intervenes, connected with the limestone on the other side of the river. One of these occurs on the south of Clonmell, and the other at Mayfield, about three miles from the noble and extensive demesne of Curraghmore, the seat of the Marquis of Waterford. But the brow of the range of hills, which lines the Suire on the south, exhibits mostly clay slate rock, supporting higher up more or less extended caps of sandstone, the strata of which are usually gently curved or arched near the top, but present a more rapid inclination, where they are abrupted on the north and the south. The border of sandstone below, adjacent to the vale, dips still more rapidly. On the south side of the road, which leads from Clonmell toward Dungarvan, we perceive this rock resting unconformably on clay slate, the latter ranging east and west, and dipping 65° south, while the sandstone dips 40° toward the north, and underlies the limestone, which inclines also toward the same quarter. And at Portlaw, about two miles from Curraghmore, the sandstone rests in a conformable position upon clay slate, both rocks ranging 25° west of north and east of south, and dipping 75° toward the north of east. This sandstone border is commonly fine grained, but the caps above abound more in conglomerate, in which fragments of clay slate and quartz are the prevailing ingredients.

The clay slate base to the south of Carrick appears to range in general 25° north of west and south of east, and to dip 75° toward the west of south. From these hills we have an interesting view of the broken ridges of the Monavoullagh mountains, (frequently also called, the Cummeragh,) in which the horizontal arrangement of the sandstone strata is very distinct, even at a considerable distance, particularly when partially covered with snow, for being very abrupt and precipitous in several places on this side, the dark faces of the broken ledges of rock are strongly contrasted with the bright white lines of the snow, which rests upon them. The same disposition is also obvious on the western side, although less abrupt. In this quarter, the clay slate foundation commonly shews a dip toword the south or south-west, yet with some local inflections toward the north or north-east.

The southern side of this chain of mountains consists of clay slate, spreading in part close to the Blackwater, and immediately supporting floetz limestone in that quarter, which in its line of apposition dips toward the south. If we ascend the hills to the north of Lismore by the romantic defile or glen of Ownashad, and gain the summit of this table land of clay slate, we find the subconical and ridgy sandstone masses of the Knockmildown mountains presenting features analogous to those of the Monavoullagh. The sandstone of both these mountain masses is in general fine grained, white or tinged with red, but conglomerate also appears occasionally. The clay slate north of the Blackwater and the vale of Dungarvan ranges nearly uniformly north-west and south-east, dipping generally from 70 to 75° toward the south-west. And good slate is raised in several quarries both on this side of the chain, as in the glen of Ownashad, and on the northern side in Glen Patrick, about three miles from Clonmell. The clay slate is usually of a reddish brown, purplish, or greenish grey colour, throughout the entire mountain chain.

Lismore Castle, which has been in a great measure restored by the present Duke of Devonshire, is founded upon the floetz limestone rock, which bassets out from beneath its towers toward the north, at an angle of 30°. This castle is in itself a striking object, and has an imposing effect from its elevated site, impending over the river. From the top it commands a very fine view of the rich scenery afforded by the vale and banks of the Blackwater, the clay slate hills on the north, with the more elevated groups of the

Knockmildown and Monavoullagh mountains; while on the south we perceive the low clay slate range that intervenes between that river and the Bride, and which extends toward Dungarvan on the east. On the northern side of this range there is interposed between the clay slate and limestone a partial border of fine grained sandstone; from which Lismore castle partly derived its materials.

The eastern portion of the county of Waterford consists almost entirely of clay slate, presenting a disposition nearly approaching to that observed more westward, a range of 20° west of north and east of south, with a dip of 70° or 80° toward the south of west. In the vicinity of Bonmaghon, copper mines were formerly wrought to some extent.

§ 145. The south-eastern angle of this county is wholly composed of sandstone and sandstone conglomerate, arranged in strata remarkable for the regularity of their order and their parallelism throughout a line of coast three leagues in extent, being disposed in the same inclination of 10° toward the south from Knockaveelish headland on the western side of Waterford harbour to the extreme point on the eastern side of Tramore bay. This disposition is very perceptible from Shanoon Head, which supplies the materials of Dunmore Pier, and immediately adjoins the new harbour. From this point we obtain a view of three successive headlands to the north, of which the most northern is Creden Head; and in like manner, from the top of Red Headland, to the south of Shanoon, the view extends beyond three successive headlands toward the south, the most southern being Foylskirt Head. The sea has in some cases on this coast laid bare a clean uninterrupted sheet of the rock, exposed in one plane, at low water, for 300 yards in length, and 50 yards in breadth. The sandstone conglomerate of this coast bears all the marks of the agglutinated detritus of a primary country; consisting of rounded and angular fragments of granite, mica slate, clay slate, quartz, quartz rock, greywacke, greywacke slate, flinty slate, and hornstone, cemented by iron-shot sandy clay, with scales of mica. This rock at times presents a finer grain, and acquires the character of sandstone. The conglomerate sometimes forms a thick and apparently unstratified mass resting on the finer stratified sandstone; and sometimes it is interstratified with the latter, as well as with very fine grained reddish brown micaceous sandstone, which is of a very perishable nature. There is no determinate order in this respect, and certain strata or beds only yield such excellent blocks of building stone as are used in Dunmore Pier, by Mr. Nimmo, the engineer employed by Government in planning and constructing this new harbour. In parts of this coast, the sea has wrought out spacious caverns in the more perishable sandstone, one of which, Bishop's hole, extends inland about 300 yards, and another, Black hole, about 500 yards.

§ 146. From Dunmore, we perceive, even with the naked eye, that the base of the opposite coast in the county of Wexford consists principally of clay slate, in strata nearly vertical; but on reaching this coast, it appears surmounted by a cap of sandstone in Broomhill, which corresponds nearly with Knockaveelish head on the opposite side. A similar cap occurs more south in Templetown hill, which gradually declines toward the parallel of Loftus Hall, where it underlies the tongue of floetz limestone, which extends to the extremity of Hook Point. This limestone is arranged in very thin strata, of a few inches in thickness, dipping at an angle of 4° to 8° toward the south. It contains numerous bivalves and corallites. Its connexion with the sandstone is best seen on the eastern coast. Proceeding along this coast to the north, the limestone becomes interstratified with slate clay, and this latter rock at length predominates, alternating with very thin beds of limestone, and acquiring a much higher elevation. We now arrive at its junction with the red sandstone which lies beneath it, both rocks being in perfect conformable position, under an angle of 18° with the horizon, and a dip toward the south-west. The point of junction is just below the old castle of Houseland, where the sandstone is of a fine grain and red cast. More to the north it acquires a coarser structure, thick beds of conglomerate being interstratified with fine grained red perishable sandstone, and obtaining the higher elevation of 24°. These rocks now form a bold coast of abrupt precipices, extending to Carnyven headland, which lies eastward of the northern brow of Templetown hill and to the south of Bagebon head, (§ 74.) Carnyven head forms the northern termination of this body of sandstone, and we perceive it resting unconformably on the clay slate in the cliffs below, the sandstone dipping 16° toward the south-west, and the clay slate 75° toward the north-east.

§ 147. We have yet to notice in the county of Wexford a few detached portions of the old sandstone. The inner haven at Wexford is partly lined by four isolated patches of this rock, lying unconformably on clay slate. It is of a deep red colour, and is principally composed of fragments of quartz with some few of clay slate, cemented by iron-shot quartz. Park Point, on the south side of the haven, consists chiefly of this sandstone, arranged in strata one to two feet thick, which are sometimes separated by a thin seam of red soapy clay; and which dip from 10° to 15° toward the south-east.

At the northern extremity of the inner haven, on the western side, is another and smaller patch of red conglomerate, situated to the west of Castlebridge. The strata dip here at an angle of 40° toward the south, adjacent to the clay slate, but they acquire a lower angle in descending toward the south.

In a dell to the westward of Artramont Castle is a similar small patch; and in the demesne of Saunder's Court is a fourth, but of greater extent. This seems to constitute a shield shaped mass applied to the southern brow of the hill, yet not extending to the strand below. The strata dip 30° toward the south-east.

At Duncormack is another patch of sandstone, which comes in contact with floetz limestone.*

§ 148. At Ballyhack, and at Passage opposite, and thence upward on both sides of Waterford harbour to the confluence of the Barrow and the Suire, we find caps of sandstone conglomerate reposing unconformably on clay slate. This conglomerate is analogous in composition to that of the Dunmore coast, containing frequent pebbles of granite, but fragments of clay slate are the predominating constituents. An instructive junction of the clay slate and sandstone conglomerate may be seen on the Wexford side, to the north of the Arthurstown streamlet, nearly opposite to Passage; the former rock ranging 25° north of west and south of east, and dipping in general toward the east of north, but very much contorted; and the sandstone conglomerate dipping at an angle of 10° in a nearly uniform plane, toward the south-west.

§ 149. Clay slate, including great beds of flinty slate, and a few of greenstone, lines both banks of the Suire from its confluence with the Barrow to the city of Waterford, but on the north side it upholds old sandstone, which is connected with that extensive mass which borders the vale of Suire on the north. The clay slate, which forms high cliffs north of Waterford bridge, ranges nearly east and west, and its laminæ dip 80° toward the north, but the rock is partly subdivided by parallel seams into strata six and seven feet thick which dip 35° toward the north. (§ 113.) The clay slate contains disseminated cubical iron pyrites. Above the cliffs, the outgoings of strata of coarse sandstone conglomerate are exposed to view. These acquire greater thickness by accumulation to the north and west, inclining under an angle of 15° in that direction, and at length descend to the road and river at the distance of about 200 yards from the bridge, and as they recede from the subjacent clay slate rock they also assume a finer grain. These strata, which are one, two, and three feet thick, are not unfrequently traversed by small contemporaneous veins of quartz nearly parallel to each other, and in general parallel also to the line of the dip. The conglomerate is very similar in composition to that of the Drumdowny quarries, adjoining the Barrow and the Suire, which yield excellent millstones; the smaller components of which consist of quartz and mica in abundance, with some little white felspar; and the larger, of a predominance of white, grey, and reddish quartz, and occasionally hornstone also, of various shades of grey, yellow, and red, with a few casual small fragments of mica slate and clay slate. This rock presents a mottled aspect, from the varied patches of its colours.

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* The Saltee islands, which appear off this coast, consist, I am informed, of clay slate, supporting masses of sandstone and sandstone conglomerate.

§ 150. The Slievenaman group, (see Plate 7. No. 4. and 6.) consists of a nucleus of clay slate surrounded and surmounted by sandstone, which is connected with the sandstone hills that extend toward Thomastown on the north, and have also clay slate for their foundation. The relations of this tract are very similar to those on the south of the Suire, presenting strata, fine grained and horizontal where they have attained a considerable thickness by accumulation, but in their line of apposition to the base below following the form of the surface of this rock. Conglomerate also occurs in this quarter. The clay slate to the east of Slievenaman, extending toward Kilmagany, yields very good slate, as for example in the quarries of Inshinagloch.

§ 151. At Thomastown the sandstone crosses the Nore; and from thence follows the foot of the clay slate hills until it comes in contact with the fundamental granite to the north-west of Graige, in strata dipping 20° toward the north-west, and forming the western and north-western sides of Mount Loftus and Brookhill. After crossing the Barrow, it re-appears for a short distance to the north-east of Goresbridge, dipping 15° to the north-west, and reposing on the granite. The sandstone at these places has much the aspect of a rock compounded of the detritus of granite, in which, however, quartz greatly predominates.

§ 152. In the interior of the great limestone plain, we may remark three isolated protuberant masses of sandstone, rising from beneath the limestone, as at Moat, Ballymahon, and in Slievegoldryhill. And to the west of the clay slate country in the county of Longford, this rock may be observed occupying a more considerable space, crossing the Shannon, and extending into the counties of Roscommon and Leitrim.

§ 153. Three general observations are applicable to the sandstone tracts over which we have travelled: 1st, That the position of this rock, when in contact with older rocks, is dependent upon the declivity and form of the subjacent surface; but that as the sandstone strata accumulate and recede from the rock beneath, they tend more and more toward an horizontal arrangement. 2nd, That not the slightest vestige of organic remains has appeared in this first floetz sandstone, in the course of the observations of which I have given the result. 3rd, That this rock has not been any where seen by myself interstratified with any other rock; except occasional slight layers of slate clay; but I must add, on the authority of Mr. Richard Griffith, junior, that this sandstone does occur in patches interstratified with the first floetz limestone at Daly's Bridge on the south side of the clay slate in the county of Cavan, and again on the north-western side, toward the towns of Cavan and Belturbet.

2. *First Floetz Limestone.*

§ 154. This rock may be termed emphatically the floetz limestone of Ireland; for, with the exception of the counties of Derry and Antrim in the north, and Wicklow in the east, there is no county in the island in which it does not more or less prevail. It exhibits considerable variety of character in different parts, in colour, structure, and hardness: and in travelling over its widely expanded field, we find it, both in unmixed continuous strata, and associated with rocks of various description, being interstratified with hornstone, lydian stone, flinty slate, slate clay, swinestone, calp, clay slate conglomerate, limestone conglomerate, magnesian limestone, brown spar, trap, and porphyry.

§ 155. This great sheet of limestone comes in contact with, and sweeps round every mountain tract which we have hitherto noticed, filling up every interval and hollow between them. In its line of apposition to older rocks, it generally follows for a certain distance the inclination of surface which they present; but in the interior of the field we may observe a greater uniformity of arrangement. In the northern and greater portion, whether we examine it by crossing the country to the south from the clay slate hills of Longford, Cavan, Meath, and Louth; or follow in the same manner the rocky coast on the east, we find the general range to approach toward the east and west, and the dip toward the south. In the central portion of the tract, the arrangement is somewhat different; the limestone there constituting basins, with strata rising and cropping out around them, and including within distinct coal districts, each supported by its base of limestone, two of which are especially deserving of notice; but beyond the borders of these basins, the dip of the limestone appears to depend, as already observed, upon the position of the surface of the older rocks, with which it comes in contact. Again, in the south-western quarter of the field, the prevailing dip in the interior is toward the west or south; but the same rule still holds with respect to the portions contiguous to older rocks.

Such is the predominating arrangement throughout the limestone tract; but local variations are to be found in different parts, depending, however, partly on mere inflection. Thus, in a line drawn from the greywacke country east of Athy past Maryborough to the west, we perceive the general arrangement to approach to the horizontal, with a slight dip of 8° or 10° toward the south; but in the rock of Dunamase, one of that small range of limestone hills, which stretch across the northern front of the Castlecomer coal district, (see Plate A. No. 2.) we may observe some remarkable inflections. The rock, on which the castle stands, presents a mural precipice to the north, the strata generally inclining about 12° toward the south, yet undulating both in the line of direction and of dip. And in the inclosure on the summit, some of the strata ascend from the south under an angle of 50°, and suddenly become inclined toward the north under an angle of 40°, the inflection thus amounting to 90°. The strata which dip 40° toward the north are surmounted by others which dip only 20°. Again, the venerable remains of the ancient cathedral of Cashel are supported by a broken arch of concentric strata of limestone. They constitute the celebrated rock of Cashel, the subjacent arches of which are perfect and continuous, but of the superior, the flanking strata only remain, which approach more and more toward the vertical position in the exterior. This structure may tend to explain the occasional appearance of vertical strata in parts of the limestone field; as for instance, near Montrath on the north-eastern side, and again at Caher and Ardfennan bridge in the line of the Suire.

§ 156. The average depth of this limestone tract in the interior is probably between two and three hundred feet; if we may ground an opinion upon the elevation of the line of its outcrops, the protrusion of older rocks, both on the borders and in the interior of the field, the levels of canals, and the different elevations ascertained by the engineers employed in surveying the bogs, or in laying out new lines of navigation throughout Ireland. But in some parts of its extent, the limestone probably acquires a thickness of 500, 600, 700, and even 800 feet. The summit level of the Royal Canal is 308 feet above high water mark in Dublin bay, and the hill of Knock Drin near Mullingar, in the demesne of Sir Richard Levinge, is supposed to be 300 feet above this level; but the surface of the limestone tract ascends considerably to the north, toward Knock Ion, the Bin of Fowre, and Lough Shillin. The summit level of the Grand Canal is 264 feet above high water mark in Dublin bay, and the level between Monastereven and Athy is between eighty and ninety feet lower; and the Dunamase range of limestone hills is probably in the highest part 300 feet above this level.

§ 157. The predominant colour of the limestone throughout the field is bluish grey, of various degrees of intensity; but it is often tinged with black, and passes into deep black, particularly in those parts where it is interstratified with numerous beds of slate clay, calp, or swinestone, or where it abounds in lydian stone. The black limestone, in the latter case, is a hard compact rock, often of a siliceous nature, requiring much fuel for its conversion into lime, and from this cause sometimes unfit for the purpose. It may frequently be observed in Westmeath, Meath, Dublin, and Kilkenny.

Calp may be considered as an intimate mixture of limestone and slate clay; yet perfectly homogeneous in aspect, it seems as much entitled to the rank of a species as many other minerals which are placed under that title in systems of mineralogy. It forms the common building stone of Dublin, and may be seen to advantage in the quarries at Crumlin, where it alternates with slate clay, in beds varying from one to three feet thick, dipping gently toward the south. The common associate of calp is slate clay, sometimes containing imbedded spheroidal, or lenticular masses of clay ironstone; but the purest limestone strata are continuous, and free from slate clay or other beds. The foreign beds of these substances abound more particularly in the eastern quarter of the tract toward the coast, in the counties of Meath, Dublin, and Kildare; while, in the interior of the field, the more usual associates of the limestone are lydian stone, hornstone, or flinty slate, imbedded in isolated portions, or in alternating layers. The structure of the limestone varies, throughout the tract, from the perfectly compact to the conjointly compact and foliated, and even granularly foliated. Beds of the last kind are quarried and wrought for various purposes in the northern parts of Westmeath, and also near Tullamore in the King's county; being of a greyish white colour, and of a large granular texture.

The limestone, when associated with calp and black limestone, passes sometimes into the state of swinestone, and in those portions of the field we may frequently remark an abundance of finely disseminated particles of iron pyrites; to which, and the distribution of carbon and hydrogen in the composition of these rocks, we may in part ascribe the peculiarity and efficacy of the Lucan mineral waters, as well as of those of Golden bridge, near Dublin.

§ 158. Some very interesting relations of the limestone tract are observable on those parts of the coast of the county of Dublin, which we have not yet touched upon; and of which I have already mentioned (§ 120.) that it was my intention to give a full description; to which I now proceed.

The line of demarcation between the floetz limestone and the transition rocks, which occupy the north-eastern part of the coast, passes on the west by Knock, between Balruddery and the Man of War, whence it follows an inclined line to the south of Skerries. At Balcumin it is associated with slate clay and lydian stone, and in Baldungan hill the principal constituents are lydian stone and flinty slate; these rocks dipping gently to the south-east. But at Malvernstown and Hacketstown, which lie nearer to the coast, the limestone is remarkably pure, and free from interstratified substances, presenting in the quarry at the former place continuous strata from three to five feet thick, dipping 14° toward the south-east, which have been opened to the depth of fifty feet. This quarry furnished the cut-stone, of which Balbriggan church and tower are principally constructed.

§ 159. The strand for about a mile to the south of Skerries forms a curved sandy beach directed to the south-east, and lined in the southern part with a high bank of alluvial soil; beneath which, at the extremity, a sheet of bluish grey limestone presents itself, spreading out to the north-east, and dipping 15° in that direction. It occupies the coast to the southward for a considerable way, till it is covered by a bed of yellowish granular magnesian limestone, abounding in cavities, which are filled with masses of white calcareous spar, from the size of the fist to that of the head, nearly. The bed of magnesian limestone appears in such parts as are unbroken to be eight feet thick; it is subdivided into strata, which are sometimes traversed by small veins of brownspar; and upon these strata reposes a bed of bluish grey limestone. More to the south, we find the bluish grey, interstratified with the magnesian limestone, resting in regular conformable position, upon a coarse clay slate conglomerate, all dipping from 10° to 15° toward the north-east. The conglomerate forms a bed, between two and three fathoms thick, divided into massy strata from three feet to four and a half in thickness, and cropping out to the south-west. It consists of a base of perfect clay slate, in which are closely crowded together rounded and angular fragments of fine grained greywacke, which is the predominating ingredient of greywacke slate, quartz, and a few of limestone; those of the fine grained greywacke being perfectly similar to that of Portrane, Skerries, and the islands adjacent. The fragments are of all dimensions, sometimes appearing as complete boulders twice or thrice the size of the head. The whole rock is very firm and tenacious, and obviously compounded of the ruins of a transition country; and it constitutes a member of the floetz class, hitherto I believe unnoticed; (see note to § 54.)

To the south-westward, we observe beneath and parallel to the clay slate conglomerate, beds of bluish grey limestone, interstratified with reddish coloured limestone conglomerate, which abound in pebbles, angular fragments, and grains of quartz, and much resembles a sandstone. The bluish grey limestone covers clay slate, which is here denuded for about a square perch; (§ 132.) It is of an isabella or reddish yellow colour, and evidently the surface of the rock, in a decomposing tender state, and apparently connected with the transition rocks in the interior, which serve as a foundation to the floetz deposition. In the series of limestone beds, which I have just described, I have met with madreporites, entrochites, belemnites, and bivalves.

These beds of limestone and conglomerate, in ascending toward the south, have suffered abruption; but, a little further south, similar beds are found declining 10° toward the south, which are abrupted on the northern edge; whence they would appear to have made a part at one time of the preceding beds, which, if continued uninterruptedly, would form an arched curve in the line of their conjunction.

Farther south again, are continuous strata of limestone full of petrifactions, surmounted by a bed of coarse clay slate conglomerate, the whole dipping 25° toward the north-east. Some of the succeeding beds, as we descend, consist of a conglomerate, with a limestone base, containing pebbles of other limestone. Farther south, beds of blackish grey limestone and of conglomerate, two and three feet thick, are interstratified with slate clay three and four inches thick, dipping likewise toward the north-east: the beds of this conglomerate consisting of a confused intermixture of greywacke slate and limestone as a base, enveloping boulders, pebbles, and fragments of limestone, quartz, and greywacke slate; and through the mass are scattered portions of calcareous spar, as also entrochites and other petrifactions. These ingredients are occasionally so numerous that the stone appears at first sight like a coarse sandstone.

Farther south, the limestone strata incline gently to the southeast, and then to the south-west, forming in fact with the preceding north-eastern inclination one of those great swells or undulations, which are so common in rocks of this class. Again, a little to the south, on the northern side of a small cove or inlet, which is about forty yards across, they resume the south-eastern inclination, but acquire the higher elevation of 40°; and on the other side of the cove, the strata rise up to the southward, under an angle of 60°, so that a complete trough or basin is formed.

A little farther south, we are presented with an horizontal section, in which the curvature of the strata appears continuous in every direction; whence it would seem that they originally constituted an elliptical assemblage of concentric layers, analogous to what we have observed in the primary stratified rocks of Howth; (§ 86.) And such assemblages are probably not uncommon in the inflected strata of limestone.

From hence to the northern side of a small inlet, which is situated immediately on the north of Loughshinny bay, the limestone strata present a pretty uniform dip of 45° toward the south: and at this northern point, an horizontal section of an interesting character is displayed. A vein of breccia, seemingly vertical, traverses the beds of limestone and slate clay in a north-west and south-east direction, but without apparently displacing them. It is exposed for about thirty fathoms in length, but its termination is concealed by the sea toward the south-east, and by the soil and grass land of the bank on the north-west. This vein is very remarkable in its form, swelling out into bellies, about four feet across in the widest part, and contracting again; and consisting entirely of angular fragments of limestone and slate clay, of various sizes, embodied in, and cemented by white calcareous spar; (see Plate 13. fig. 11.)

To the south of this inlet, some of the limestone strata are most curiously interwoven with contemporaneous veins and strings of calcareous spar. The limestone is succeeded in the north-western angle of Loughshinny bay by a body of black slate clay, about forty fathoms wide, resting in the first instance conformably on the limestone, but subsequently exhibiting most singular inflections and contortions. This slate clay consists of thin layers, alternately hard and soft, and it abounds in pyritous particles; whence it is extremely subject to decomposition, forming alum and sulphate of iron. Limestone now appears resting on the thick bed of slate clay, and dipping 45° south. It forms strata from three inches to two feet thick, frequently alternating with slate clay. The limestone is here also curiously interwoven with contemporaneous veins of calcareous spar, sometimes in a kind of net work; which, however, are confined in every instance to a single stratum. Repeated inflections of these beds now take place, rising under an angle of 65° to 70° on the north side; but on the south side, sweeping off at an angle of 30° to 35° with the horizon.

§ 160. Analogous, yet gentle undulations in the beds of limestone and slate clay are repeated throughout Drummahaugh headland, which forms the southern side of Loughshinny bay, and is the site of an ancient Danish encampment. These inflections may be compared to the gentle swells of the sea, the ridges sometimes ascending in their upper part into the pointed form. But these rocks, which are well exposed in the cliffs on the north, the east, and the south sides of the promontory, preserve in general a range from east to west, with a dip toward the south. In the eastern face of this headland some interesting facts are also exhibited; a second breccia vein being visible, both in a vertical and horizontal section of the cliff. On the beach it is four feet wide, but in ascending the cliff it diminishes to about one foot and a half in width. It ranges also north-west and south-east, and dips 80° to the north-east; and in traversing the limestone and slate clay it produces an obvious derangement, the beds on the northern side of the vein being horizontally disposed, while those on the south form a declining curve. The composition of this vein is perfectly similar to that already noticed; (§ 159.) and the white base of calcareous spar is strongly contrasted with the fragments of limestone and slate clay, some of which are even two feet and a half in length, and one foot in breadth; (see Plate 13. fig. 12.)

North of this vein the beds are traversed by four small parallel veins of calcareous spar, which do not produce any derangement: and a little farther north, we encounter another breccia vein, preserving the same north-west range and north-east dip, and composed chiefly of calcareous spar, containing some fragments of limestone and slate clay. This last vein no where exceeds six inches in width, and it is gradually reduced in both extremities to a mere fissure, the filled vein not being traceable for more than twenty feet in length.

It is impossible to contemplate these and analogous phenomena (§ 95.) without believing that one class of veins, at least, have originated in open fissures, which have been subsequently filled in part from above.

§ 161. To the south of Drummahaugh headland, the beds of limestone and slate clay acquire a nearly vertical position, but they subsequently subside into an angle of 40° toward the south; and this disposition is preserved in the north side of Rush bay, where the limestone rock presents one clean uninterrupted sheet for about two hundred yards in length. Alluvial matter now occupies the beach to the town of Rush.

§ 162. On the south side of the bay of Rush, and east of the quay, beds are visible in alternation with each other, consisting of pure compact limestone, black slate clay, and limestone conglomerate, composed of a base of bluish grey limestone, both compact and foliated, and involving numerous, closely crowded, rounded and angular fragments of clay slate, quartz, limestone, and rarely also of compact greenstone; the two first mentioned substances predominating. The ingredients of this conglomerate vary in size from that of small particles to masses as large as half the head; the finer grained variety of the compound resembling sandstone. The alternating beds of conglomerate, limestone, and slate clay vary in thickness from a few inches to two and three feet; those of the conglomerate, in some of which I observed numerous entrochites and madreporites, being the most considerable. They range 20° south of east and north of west, and dip 60° toward the north. In proceeding toward the martello tower, the beds of conglomerate gradually diminish in proportion, being succeeded by massy beds of blackish grey limestone, with a few interjacent thin beds of slate clay. This limestone is flat conchoidal and even in fracture, with a glimmering lustre, but when examined with a lens it is found to be composed of minute foliated grains.

Farther south, the slate clay rather predominates, but the same range and dip are observable. At the point of the headland, the beds gradually acquire a vertical position; and shortly after, they begin to decline toward the south at the high angle of 70°, yet still ranging as before, 20° south of east and north of west; and they preserve this high elevation and regular range, as far as visible along the strand on the south side of Rush headland, except in the latter part, when they seem gradually to acquire again a northerly dip of 60°.

§ 163. The rocky coast, called Rob's Walls, on the south side of Malahide bay, consists wholly of floetz limestone, abounding in entrochites, madreporites, and other organic remains. The strata exhibit four or five great undulations from north to south, in which the highest angle is about 40° and the lowest 5°; the general range being nearly east and west, or more precisely, between 15° south of east and north of west, and 10° north of east and south of west.

§ 164. Floetz limestone sweeps round the western foot of Howth, from the strand below the town on the north, to Sutton on the south side; the bluish grey being in both cases associated with the yellow magnesian limestone. The martello tower, below the town of Howth, stands on beds of limestone gravel and sand fifty feet deep. Beneath this alluvium, we perceive bluish and blackish grey limestone, in strata, abounding in entrochites, corallites, and bivalves, ranging 18° east of north and west of south, and dipping 13° toward the west. High banks of alluvium line the south side of the new harbour, and within the basin rocks of magnesian limestone protrude; but to the west of the western pier are crags of bluish grey limestone irregularly intermixed with the magnesian, the one stone being frequently enveloped by the other. They extend as far west as the Black Rock, which is visible only at low water; and beyond them, grey limestone is alone to be seen, appearing in the banks under the soil, in strata, two and three feet thick, dipping toward the north-west at an angle of 25° to 30°. But more inland, in the quarry below the public road, they dip 40° toward the same quarter.

On the south-west side of Howth, near Sutton, the grey and the magnesian limestone appear to be interstratified, and also irregularly intermixed, with a slight inclination toward the south-west; the latter rock being principally observable at the surface. Both here and on the north side of the peninsula, the magnesian limestone is traversed by small veins of brownspar, and it contains cavities filled or lined with calcareous spar and brownspar.

§ 165. Limestone is visible at low water, in three places on the shore beneath Booterstown, on the south side of Dublin bay, in strata dipping 15° to 20° toward the north-east. It is bluish grey, foliated granular, with frequent small veins of brownspar. At Williamstown on the coast, farther east, granite rock appears; and about two perches north of it is a low insulated rock of limestone, of the same description as that under Booterstown.

§ 166. In the line of the Dodder, between Classon's bridge and Miltown bridge, magnesian limestone, traversed by veins of brownspar and associated with common grey limestone, may be observed dipping at an angle of 5° toward the north; while at a short distance to the south, the subjacent granite becomes visible. But, in the whole tract between the Dodder on the south and the Liffey on the north, as well as to the north of this river, in which so many quarries are opened both for calp and for limestone, the general direction of the beds is east and west, with a dip to the south at an angle seldom exceeding 15° to 20°. The same disposition is manifested, more to the west, in the line of the Grand Canal, extending toward Newcastle; yet, near Hazlehatch, as already remarked, (§ 135.) the limestone where it adjoins the subjacent rock, which is here principally greywacke slate, dips to the north, or according to the natural declivity. I have before observed, (§ 155.) that this conformity of position to the declining surface of the contiguous rock, is general throughout the field, whether the limestone rest upon granite, on clay slate, or on sandstone, which rocks commonly occupy more elevated ground than the adjacent limestone.

§ 167. The county of Wexford is almost as destitute of limestone as that of Wicklow, and contains only three detached patches of that mineral. One occurs at Kerlogue, one mile south of Wexford, forming a low narrow slip which follows the coast for four or five miles to the southward, being bounded principally by quartz rock to the west and north. The limestone strata dip mostly at an angle of 15° to 20° toward the south, and consist of bluish grey limestone including corallites and bivalves, and associated with a brownish grey, fine granular, magnesian limestone.

At Duncormack is a second small district of limestone, which extends from the coast into the interior, for three or four miles in a north-east direction, toward Scarbridge and Brideswell, and to the north toward Taghmon. It is mostly bounded by clay slate and quartz rock, except on the south-west, where it comes in contact with sandstone conglomerate. This limestone is generally of a reddish brown cast, seemingly derived from the conglomerate in its vicinity.

Hook Point, the southern extremity of the county, consists, as already stated, (§ 146) of limestone resting on the red sandstone and sandstone conglomerate.

§ 168. The association of the floetz limestone with brownspar has been noticed by the late Mr. Tighe in his Statistical Survey of the county of Kilkenny;* and by Mr. Richard Griffith, junior, in his valuable tract on the Castlecomer coal district,† to which works I beg leave to refer, not having myself had an opportunity of examining the places where that association is to be observed.

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* Page 91 to 93.

† Geological and Mining Report of the Leinster Coal District, page 7 to 12.

§ 169. It remains for me to consider only the connexion of the limestone with trap and porphyry.

Croghan hill, near Philipstown in the King's county, (see Plate 6. No. 2.) is a protruding mass of trap rocks, rising about 500 feet above the surrounding country, distinctly supporting on its north-western and south-western sides the floetz limestone, which in the former quarter dips 60° toward the north-west, and in the latter 25° toward the same point, but acquires a higher elevation in receding from the trap.

The body of Croghan hill consists of trap conglomerate, which is more or less exposed on every side, and exhibits tabular masses dipping toward the north-west; in the southern part under so high an angle as 80°, but in the northern of 60° only. Low down on the north-eastern side, where the hill is rocky and precipitous, appears a hard, firm, compact rock of a bluish grey or pale lavender blue colour, arranged also in tabular masses, and dipping likewise 60° toward the north-west; and at the bottom of the precipice, the rock acquires a darker colour, being greyish black. This is an intimate mixture of hornblende and felspar, containing small disseminated particles of hornblende, calcareous spar, quartz, and iron pyrites. The grey or blue rock, on the other hand, is mixed with shades of muddy pink; and seems to be an intimate mixture of compact felspar and carbonate of lime, of considerable tenacity, with a splintery or flat conchoidal fracture and translucent edges. It contains frequently disseminated particles of calcareous spar, of hornblende, and of iron pyrites; and sometimes acquires an amygdaloidal character, the portions of calcareous spar and hornblende assuming a roundish form. This general diffusion of calcareous matter through the rock, renders it very easy of decomposition near the surface; and the carbonate of lime being gradually withdrawn by weathering, a porous spongiform mass commonly remains, which in the estimation of some mineralogists might pass for the scoriæ of lava, or even for pumice-stone. The rock may be traced in different stages of decomposition, from the firm solid compact state to the most porous; the former always exhibiting some degree of effervescence with acids; the latter none whatever, when the pores are completely empty.

The base of the trap conglomerate is an intimate mixture of greenstone and carbonate of lime; in which are imbedded angular fragments, sometimes of considerable size, of limestone, greenstone, and lydian stone. The compound shews in general on the fresh fracture a light bluish grey base, but this being extremely subject to decomposition, and disintegrating, there remains a coherent mass of unchanged fragments with numerous cavities and interstices; presenting a great variety of colours, dirty brown, yellow, and even brick red.

The soil of this hill is remarkable for its fertility, yielding uninterruptedly the most abundant green and white crops, without any manure whatever.

Between Croghan hill and Philipstown, about one quarter of a mile from the latter place, massy strata of greenstone appear in the townland of Castle Barnock, dipping 45° toward the west. The rock is compact, fine grained, and of a blackish green colour, containing disseminated particles of hornblende and calcareous spar. About half a mile to the west from the place where it occurs, are quarries of limestone, which contain subordinate layers of lydian stone, and thin beds of slate clay, dipping 16° toward the east. And in the limestone quarry at Philipstown to the south, a similar arrangement is observable, the beds dipping toward the east, but at an angle of 32°; whence it seems probable that the trap supports the limestone in this quarter also.

§ 170. In the Kildare range, the hill of Allen (see Plate 6. No. 1.) is composed of one great body of granular and compact greenstone, and greenstone porphyry, which appear all round the base, on the sides, and on the summit, in numerous protuberant rocky masses, without any mark of stratification. Some of the greenstone is remarkably crystalline, consisting of large crystals of hornblende with acicular crystals of felspar.

Grange hill and the Chair of Kildare constitute in fact one hill, with a slight hollow between them. The floetz limestone of the latter appears to be disposed in massy strata, four and five feet thick, dipping 45° toward the south-east. It is generally greyish white, but sometimes mottled, reddish brown being intermixed with shades of bluish grey and white; and it contains bivalves and entrochites. In its outgoing to the north-west, the limestone presents a rocky face or small escarpment, beyond which is a slight hollow, forming the southern foot of Grange hill. In the road leading from a farm-house on the other side of this hollow to the hill above, the rock which appears at the surface is compact greenstone, in some places porphyrytic; but near the surface it is easily frangible, and being much decomposed, acquires almost the appearance of wacke. Beneath, however, it assumes a greater degree of compactness and solidity, and its true character is not to be mistaken. When we consider the dip of the limestone of the Chair of Kildare, and the general form of this hill and of Grange hill respectively, it seems highly probable that the greenstone is subjacent to the limestone, and this probability is increased by the following fact. The greenstone which I have just described contains marine exuviæ; and where adjacent to the limestone, it appears to be intermingled with calcareous matter. The organic remains are principally bivalves, anomites, pectunculites, and terebratulites, with entrochites in smaller number. In the more solid stone we sometimes find the shells themselves; but nearer to the surface they have in most cases wholly disappeared, leaving only distinct and delicately marked impressions of the surfaces of the valves, the space between them being occupied by greenstone. In the same manner, casts of the entrochite occur, in the form of hollow and solid cylinders. These organic remains seem to be confined to that portion of the rock, which is in the vicinity of the limestone; for none are to be discerned in the remaining mass of the hill, which exhibits every where rocky protuberances from one continuous body of greenstone and porphyry. The only other rock visible is clay slate, standing in strata nearly vertical, which appears low down on the western side and at the base of the hill, in that quarter; (§ 137.)

§ 171. But, it is in the county of Limerick that the interstratification of the floetz limestone with trap rocks becomes distinct and well marked, both on the large and on the small scale: and if we examine the calcareous tract from the Bilboa mountains on the north, for some distance south of the parallel of Pallis and Caherconlish, we may trace these relations in succession.

§ 172. On the north side of the valley, I have already noticed (§ 139.) the outcrop of the floetz limestone at Castleguard, where it probably lies upon the sandstone of the Bilboa mountains, the dip being conformable. If we now take post on the northern brow of Pallis hill, which is elevated about 500 feet above its immediate base, and overlook the country, we perceive the surface of the vale below diversified by unequal, indented ridges of slight elevation, which cross the valley under an oblique angle, in a nearly parallel position. These are in fact the successive outcrops of massy beds, composed of limestone and trap, in alternation with each other; and the south side of the valley is bordered by low hills and slight eminences, which partake of the same character. The country is thus constituted of seven or eight great alternating beds of limestone and trap, independently of the subordinate divisions that arise from the interposition of smaller beds of limestone in the latter; as for example in Pallis hill. The general inclination of these massy beds is toward the west or south, at an angle of 10° or 12°. But the trap beds frequently possess in themselves an internal arrangement different from, and independent of the general disposition. (see also § 71.)

§ 173. The trap rocks, which I have observed in this district, are iron claystone, greenstone, basaltic greenstone, all of them occasionally porphyrytic; basalt, both amorphous and figurate; amygdaloid, felspar porphyry, and trap conglomerate. These rocks exhibit those endless varieties of aspect, which every where distinguish them, but of which an adequate conception can scarcely be conveyed in words. I shall therefore attempt to describe only the prominent characters of the more distinct varieties.

The basalt is greyish black, minute granular, displaying glimmering facettes when exposed to the sun. It passes into basaltic greenstone of a blackish green, and this into compact greenstone of a greenish grey colour. These generally contain more or less of crystalline hornblende. The amygdaloid has commonly a base of decomposing greenstone, or of wacke, of a greenish grey or brownish red colour, enveloping nuts and points of calcareous spar. In the felspar porphyry, the base is usually light yellowish or reddish brown, or greenish grey, with a fracture passing from close granular to compact, sometimes approaching to the nature of clinkstone porphyry, and the contained crystals being of glassy felspar. This compound passes into claystone, which sometimes becomes so charged with iron, as to pass into iron claystone, both red and black, which are either compact or porphyritic. The trap conglomerate consists of an intermixed base of trap and limestone, cementing fragments of both the same kinds of stone; and in the limestone of this conglomerate I have observed organic remains.

§ 174. In crossing the valley from Castleguard toward the south, we travel over continuous strata of bluish grey limestone for nearly two miles, which are succeeded for about one mile by red trap, arranged in massy strata four and five feet thick, both rocks preserving the same dip of 10°. This bed of trap probably underlies the limestone bed of Mount Catharine, which seems in its outgoing to form the north-eastern and eastern base of the trap range which extends through Knock Rua, Knock Dirk, and Kilteely hills; (see Plate 7. No. 5.) But, in the vale, about one mile to the north-east of Mount Catharine are the two slight eminences of Tullogh and Cross: which constitute in their northern extension the low elevations called Brackheel and Coolanapish hills, and the whole form together one great bed of trap, principally composed of porphyry of various shades of red, brown, grey, and green, disposed in thick massy strata. To the eastward of Cross is limestone again, and beyond this, still more east, Knock Hourach, which also is composed, I am informed, of trap, resting on limestone: and this I apprehend to be the eastern limit of the trap beds.

§ 175. Limestone rock is to be seen in several places low down on the eastern flank of the trap range of Knock Rua, Knock Dirk, and Kilteely, and it is evidently the basis of this range which appears to constitute one great prominent bed. The same rock is visible also on the western flank, occupying the hollow which separates this range from Pallis hill, of which last hill it forms the eastern and north-eastern base.

In Knock Dirk the rock is exposed in many places, and on the south-western side near the summit it is evidently composed of strata from one to three feet thick, dipping at an angle of 36° toward the west; but low down on this side it presents no distinct stratification. The same observation may be applied to the exposed rocky parts of Knock Rua, which in the upper portions appear disposed in strata from six inches to two and three feet thick, dipping 65° toward the west, while in the deeper the rock is more solid, massy, and less divided. But in proceeding westward, the stratified rock opens like a fan, the strata gradually acquiring an opposite inclination toward the east. In Kilteely, the strata are from one to three feet thick, dipping 70° toward the west. The composition of these three hills is very similar, consisting mostly of varieties of felspar porphyry; but in the lower grounds, on the north-western side of Kilteely, the rock approaches to basalt and greenstone, yet is still porphyritic.

§ 176. The structure of Pallis hill is more complex and interesting. The base on the east, as already observed, appears to be limestone. The superincumbent beds present a rudely terraced outline, the higher receding from the lower, while in their aggregate they constitute a mass of a horse-shoe form, whose concavity is turned toward the west. And in following these beds around the convexity of the curve, wherever their outcrops admit of observation, we generally find them dipping toward this concavity, converging, as it were, toward a common centre.

The predominant rock of Pallis hill is trap, of every variety that I have hitherto described. It is distinctly interstratified with limestone; and from the frequent occurrence of fixed blocks of limestone and of limestone conglomerate around and high up the hill, I am led to infer that these are projections of contemporaneous imbedded masses, if not portions of continuous beds, which are concealed from view by the covering of soil. The alternations are best displayed toward the north-eastern foot of the hill; and if we follow the public road from the village of Pallis to that of Nicker, situated more to the west, we may observe the order of succession.

Close by the former village, we find in the road itself, firm rock of basalt, porphyry, and amygdaloid, and immediately below them, limestone. Farther on, blackish grey trap appears on the southern side of the road, and a few perches beyond we come to a limestone quarry on the same side, exhibiting strata three and four feet thick, dipping at an angle of 12° or 15° toward the west. Three of the solid strata are laid open in the quarry, and above them we perceive a thin tabular rock, the surface of which is in general decomposed; but on breaking into the thicker tabular masses, the true nature of the rock becomes displayed; being in fact an intermixture of limestone with bluish grey trap.

At the village of Nicker blackish grey trap crops out immediately above the chapel, arranged in distinct strata, three, four, and five feet thick, dipping from 20° to 30° toward the west, and therefore conformably to the limestone which we left below. This bed of trap extends upward about ten fathoms, and is then succeeded by a bed of limestone, about fifteen fathoms thick, whose strata repeatedly crop out at the surface, and are disposed conformably to the subjacent trap. The limestone is surmounted by trap, which seems to occupy the hill to the very summit, as no other rock appears in this quarter; and this body of the trap is probably nearly forty fathoms thick.

The composition of the trap of Pallis varies very much in different parts of the hill. It is frequently of the nature of greenstone and basaltic greenstone, and it exhibits also red, brown, grey, and green porphyries; but in the north-western quarter basalt more particularly predominates, both low down on the northern face, and high up on the north-western summit.

The lowest visible rock at the northern foot, in the plantation at Linfield, is a compound of pale greenish trap and calcareous spar; but in the vale below, the bluish grey limestone is quarried in continuous strata four and five feet thick, dipping 10° toward the south. Above the green trap in the plantation, are the remains of some slight mining trials, made a few years since in quest of coal, by which, it is said, some little wood-coal was obtained. The trials appear to have been conducted in a black carbonaceous slate clay, of which a small portion is visible in the road leading to the hill; and this appears to support red iron claystone, which gradually passes into and supports amorphous trap, which last is covered by columnar basalt. This basalt is quarried for building stone and other purposes, and a colonnade is thus exposed to view 70 to 80 feet in height, facing the north, and about 60 yards in breadth. The columns are inclined toward the north under an angle of 75°; but the bed which they compose is slightly inclined toward the south; they are of irregular figures, disposed toward the four, five, and six-sided form, and from two to five feet thick; and consist either of genuine basalt, or of compact basaltic greenstone, both containing more or less of hornblende, and displaying by weathering large globular distinct concretions, which are composed of concentric lamellar layers.

Below the columnar basalt, but not in contact with it, may be observed in the public road to the eastward, many varieties of porphyry, and amygdaloid; but so little of them is exposed, that their relations are not easily ascertained.

The red iron claystone crops out to the westward, and a quarry has been opened upon it to the depth of ten and twenty feet. This rock is here in part so thinly stratified as to become almost slaty, and it may be raised in flags, which however are not continuous, being divided by cross fissures. The strata, which are from half an inch to six inches in thickness, are arranged with as much regularity as a pile of boards; but in depth they become thicker, dipping at an angle of 10° toward the south. The rock of which they consist is of a dark brownish red, or even brick red colour, very compact in the cross fracture, hard, and heavy, containing much iron in its composition. In the direction of the stratified structure of the stone, occur spots of calcareous spar, with earthy crystals of felspar; some of the layers consisting wholly of this compound.

About twenty fathoms perpendicularly above the red iron claystone, limestone crops out to the surface, in strata from one to two feet thick, dipping at an angle of 27° toward the south-east into the hill; but little of the rock is exposed to view. From hence upward we observe only greyish black basalt, amorphous and columnar, and containing hornblende. The columnar portions are confined to the southern side of the extreme north-western part of the hill, appearing as rude projecting pillars, similar in form and composition to those of Linfield below, but not so well displayed, rising only a few feet above the surface. There are two clusters of these pillars, with a slight interval between them.

The protruding blocks of limestone and limestone conglomerate, to which I have already adverted, are to be found in various parts of the north-western and south-western arms, and in the exterior curve of the hill to the east; in some cases directly in contact with the trap rock. The limestone conglomerate consists of a base of limestone or calcareous spar, enveloping rounded and angular fragments of trap and limestone; and in the conglomerate, entrochites are to be found, and also the anomites productus of Martin. This stone occurs also in loose pieces scattered over the hill, generally in a crumbling or decomposing state.

We may here remark that as Pallis hill bears some analogy to Croghan hill, in the King's county, in the nature of its mineral structure, so it does also in the quality of its soil, with which it may vie in fertility. These hills are distinguished for the permanency of their verdure.

§ 177. Immediately to the westward of Pallis hill, are the two small low hills of Mount Sion, consisting of limestone strata, dipping gently toward the south. Beyond these hills to the north-west, and adjoining to the vale below, is the slight eminence of Drumbawn, principally composed of reddish brown trap, disposed in massy strata, five or six feet, or more in thickness, with a slight inclination toward the south. More to the westward we find the limestone hill of Knockeen, abrupted toward the vale on the north, and displaying strata from six inches to three feet thick, which dip 12° toward the west. And between Knockeen on the north, and the village of Caherconlish on the south, is the small hill called Baluilth, wholly composed of trap; being in general a bluish grey close grained rock, much intermixed with carbonate of lime; and sometimes it appears as a perfect trap conglomerate, in which entrochites are discernible.

§ 178. To the south of the village, and at the northern foot of Knock Rua Caherconlish, just above Major Wilson's house, limestone strata crop out, dipping 45° toward the south. The hill above is entirely composed of trap, in massy strata, four, five, and six feet thick, dipping 20° toward the east of south. These rocks consist principally of porphyries, red, brown, grey, and green; but trap conglomerate also occurs. Of this description are also the rocks in the larger and more southern part of Knock Rua, and so also in a third hill of the same range more toward the south-west, called Balloch-bega, at the northern foot of which limestone rock is also visible.

I did not extend my researches to the southward of this quarter, but from the form of the country as seen from Pallis hill, I am led to suspect that there are one or more great beds of trap to the south of Knock Rua and Caherconlish. There is one hill in particular, situated apparently about three or four miles to the south of this Knock Rua, which much resembles it in form.

In this series of trap rocks, I have no where observed any of the zeolite family.

§ 179. In the association of the floetz limestone of Ireland with trap rocks, we perceive some analogy to what is observable in Derbyshire, where the mountain limestone is interstratified with trap; commonly with greenstone and amygdaloid, but also with basalt, of which last I have distinct specimens from that country; and this analogy is supported in other respects. The coal rocks of Derbyshire rest upon the limestone and trap; and a few miles more to the south of the district we have been considering, near Charleville, we find our limestone field bordering upon and supporting the Munster coal tract. And, if we examine the organic remains contained in the two limestones, we perceive a farther coincidence; entrochites, madreporites, tubiporites; also ammonites, euomphalites, orthoceratites, many species of anomites, terebratulites, being found, abundantly, in both. And this analogy extends, in many respects, to the mountain limestone of the northern and other parts of England, as well as of Wales.

§ 180. It is not my intention to enumerate in full detail the petrifactions, which occur in this widely spread field of floetz limestone in Ireland. The subject is so extensive, that it might with greater propriety form the subject of a separate work. I shall confine myself to a few only; remarking that, in most parts of the field, several of the petrifactions noticed above, as well as of those which follow below, may be casually met with.

In the collection of Dr. Stokes, Professor of Natural History in the University of Dublin, from the King's county limestone, may be observed, terebratula ornithocephala, terebratula obsoleta, amplexus coralloides, orthocera lævis, orthocera annulata, *(Sowerby)* anomites productus of Martin, helicina of Lamarck, madreporite junci lapidei, *(Parkinson.)* And in a collection belonging to the same gentleman from Cloghran, within a few miles of Dublin, I have seen terebratula lateralis, terebratula biplicata, euomphalus pentangulatus, *(Sowerby)* turbinated madreporite, *(Parkinson)* and several species of anomites.

In the limestone at Sutton, I have observed entrochites, ammonites, euomphalites, corallites, terebratula biplicata, terebratula ornithocephala, anomites productus, several other species of anomites, madreporites, orthocera lævis, orthocera annulata, amplexus coralloides, spirifer cuspidatus, *(Sowerby)*. In the county of Limerick limestone I have also remarked, amplexus coralloides, terebratula biplicata, euomphalus pentangulatus, cardium hibernicum, *(Sowerby)* anomites productus, entrochites, &c. In other portions of the limestone field, have also been found, mytilites, pectinites, pectunculites, tellinites, turbinites, trochites, belemnites, ostracites, patellites, and echinites, both the body and spines.

The Sutton limestone is connected with that of Howth, St. Doolagh's, Feltrim, and Cloghran; and these exhibit more or less of the same organic remains. But one of the most remarkable petrifactions, that has occurred to me in the floetz limestone, was found at Sutton. It appears to be of vegetable origin, and it bears some resemblance to Fig. 1. Plate 25. of Martin's Petrif. Derbien., which is an impression on the sandstone of the Derbyshire coal tract. I have analogous impressions also on the roof shale of the Killenaule coal district; but the Sutton petrifaction is not compressed. The portion displayed is part of a stem, nine inches long, one broad, and three quarters of an inch deep, consisting in the interior of dark grey carbonate of lime, the surface of which is marked with close equal longitudinal striæ, with some appearance of joints; but these are not distinct, from the fractured state of the stone. Some botanical friends, to whom I exhibited this specimen, consider it to be an equisetum. I have not met with any similar specimen in any other part of the limestone tract.

§ 181. The limestone field has afforded indications of metals in many parts of its extent; principally of lead and copper. Disseminated iron pyrites, copper pyrites, blende, and galena may casually be observed in the limestone; but veins also have been found, which have yielded considerable quantities of galena, so far as they were wrought; the veinstone being commonly calcareous spar, sometimes accompanied by brownspar, and more rarely by fluor spar. The floetz limestone of Ireland is, however, in general, singularly ill calculated for the conduct of mining operations, the position of that of England and Wales being much more favourable. In Ireland, this formation occupies the lowest and richest part of the country, and frequently supports a considerable depth of alluvial matter and soil. Hence mines cannot be freed from water without machinery, and the value of fuel and the damage of land become likewise important considerations in such undertakings. To these causes it is principally to be ascribed, that whatever mining operations have been carried on in this field, have been very superficial, seldom attaining to a greater depth below the surface than ten or twenty fathoms. In this manner, nevertheless, excellent galena has been raised at different periods near the strand at Clontarf; so also near Dolphinsbarn, Kilmainham, Castleknock, and Cloghran in the county of Dublin; and at Floodhall in the county of Kilkenny. And in the northern part of Meath, near Beaupark, adjacent to the Boyne, copper ore was formerly raised.

3. *Coal Formation.*

§ 182. As it does not enter into my plan to consider the extensive coal tract in Munster, which rests upon and borders our limestone field on the south-western side; I shall confine myself to the Leinster coal tract, and more particularly to the Killenaule coal district, of which no distinct account has yet appeared before the public. A valuable Report has been already published upon that of Castlecomer, by Mr. Richard Griffith, junior,* to which it is sufficient for me to refer. But in order to connect that district with the country extending eastward to the sea, and also to afford grounds of comparison with the Killenaule coal tract, I have with Mr. Griffith's permission drawn his section of the former district, upon the same scale as my own sections; (see Plate 14. No. 1. 2. 3. and 4.) The third and smallest district of coal beds which lies to the north-west of Freshford, is comparatively unimportant; having afforded, it is said, only an indifferent culm.

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* Geological and Mining Report of the Leinster Coal District.

§ 183. The Killenaule district, like the other portions of the Leinster coal tract, forms a low range of hills placed upon, and elevated above the floetz limestone. It is about six miles broad in the widest part, and eighteen miles in length, extending continuously from near Freshford on the north-east to the brow opposite to New Park, about five miles south-west of Killenaule; where a limestone flat intervenes, cutting off some detached portions of the coal rocks, that extend even to Cashel, about three miles farther.

This district varies in its elevation, being highest and most abrupt toward the north-western side, the hills in general fluctuating in that quarter between three hundred and six hundred feet in height above the limestone plain; while toward the south-east the surface gradually declines, all the principal streams flowing in that direction. The aspect of the surface is various, but it commonly presents round backed hills, with intervening hollows.

§ 184. The limestone border generally follows the foot of the hills, but in some cases it rises half way up the brow; as in the line extending on the north-western side from Kilcooly toward Freshford; and in others, it even occupies the summits, forming the whole of the exterior hills, as in a range of about three miles in length, between Killenaule and New Park on the south-west.

The limestone and the superincumbent coal beds exhibit a more rapid inclination on the north-western side of the district than on the south-eastern, as the following observations testify.

Thus, *on the north-western side,*

At New Birmingham,	
the limestone dips	33° toward the south-east.
the shale and grit dip in the ravine above	33° . . .
and higher up	24° . . .
At Pointstown brow,	
the shale and grit dip	30° . . .
At Millesane,	
the limestone dips	24° . . .
At Littlefield,	
the shale and grit dip in the brow above	40° . . .
Above Kilcooly,	
the limestone dips in the brow	20° . . .
and the shale and grit dip	20° . . .
But in the south-western quarter, at the foot of the hills opposite to New Park,	
the limestone dips	12° toward the south-east.
and the shale and grit dip	12° . . .
and in the brow above	5° . . .

On the south-eastern side,

Below Potrath cover,	
the limestone dips	12° toward the north-west.
and the shale	12° . . .
And at Lismullin quarry,	
the limestone dips	12° . . .
and the shale, above it	12° . . .
while the grit in Glengall hill, extending toward the southern outcrop of the Copper or Raygrass seam,	
dips also	12° toward the north-west.

These observations tend to shew, that the main south-eastern and north-western dips occupy about an equal portion of the breadth of the limestone trough or basin, or nearly three miles each, inclined toward the common centre.

§ 185. In the escarpment on the north-western side, above the limestone, we observe in succession,

a. Shale.
b. Gritstone.
c. Shale, with subordinate beds of grit.
d. Gritstone again, this last being the principal bed of sandstone, and, when not surmounted by superior beds, constituting the main body of the elevated part of the coal hills. It is the *seat rock* of the coal.

This seat rock undulates repeatedly in a direction from the north-west toward the south-east, and could we divest it of the upper beds, we should perceive unequal ridges affecting in general a north-eastern and south-western direction, with intervening hollows, troughs, or basins, whose average breadth bears but a small proportion to their length.

These hollows are occupied by beds, which succeed each other in the following order, beginning with the lowest:

a. Seat grit rock.
b. Fire clay, resting on the seat rock, and forming the immediate floor of the coal.
c. Coal.
d. Roof shale, or slate clay, being the cover, with nodules of clay ironstone.
e. Top grit rock.
f. Top shale, at times with discontinuous layers of nodular clay ironstone.

In some instances, this series appears to be repeated, two or more seams of coal lying in the same trough, one above another.

These troughs, or basins, are generally from fifty to seventy yards deep from the surface to the bottom of the channel of the upper bed of coal; the middle of the channel being flat, while the sides gradually acquire a higher angle of elevation toward the outcrop of the coal. The breadth of these troughs is usually 500, 600, or 700 yards, at the surface.

§ 186. The structure, here described, may be clearly traced by crossing the country from Littlefield on the north-west toward Lismullin on the south-east, passing through the coal field of Mr. Langley of Coalbrook, and leaving Ballingarry on the east. It is the line represented in the section of this district; (see Plate 14. No. 4.)

We thus traverse a succession of coal troughs, bearing the names of the Five Mile Seam, Knockbrack, Coalbrook, Canal, Clashduffe, and Copper or Raygrass troughs. All of these, except the first, are found on Mr. Langley's estate of Lisnamrock, but they extend into adjoining properties in a north-east and south-west direction, with the exception of Knockbrack and Copper troughs, which extend from Mr. Langley's property, only toward the south-west.

The north-western outcrop of the Five Mile seam is within a quarter of a mile of the declivity on that side; and the south-eastern outcrop is about 600 yards distant. On either side the seat grit rock may be traced rising up to the surface; but in proceeding across the country to the south-east, this rock may be observed gradually forming arches between the several troughs, which are either entire and flat at the top of the arch, or sometimes broken, presenting interrupted strata with opposite dips. The beds which surmount the seat rock are sometimes broken in a similar manner; and these fractures afford in one instance an opportunity of observing a repetition of the series. Thus, in the broken arch on the north-western side of the Coalbrook trough, we perceive a seam of coal about thirty-five yards below that of Coalbrook, being about twenty inches thick, and below this occurs another seam, about ten inches thick, at the distance of thirty yards. Beyond Copper trough, the seat grit rock rises up to the south-east in Glengall hill, about half a mile to the west of Ballingarry, under an angle of 12°; which position, as before observed, (§ 184) the grit, shale, and subjacent limestone preserve in this quarter. Hence no coal has been found to the south of the parallel of Glengall.

§ 187. Two of these coal troughs sometimes conjoin in a part of their course; that is, the coal of one trough in ascending to the southward forms a continuous line with the coal of another trough ascending to the northward, so as to form a kind of saddle between them. This happens in the south-western part of the field of the Coalbrook and Canal troughs; but in the north-eastern direction they separate again, each following its own course. The same appearance exists in the central part of the field, between the Canal and Clashduffe troughs, but they separate again, both toward the north-east and south-west, the seat rock coming to the surface in both these instances, as well as in the former. Such appearances seem to be owing, partly to the unequal elevation of the ridges of the seat grit rock, and the consequent unequal distribution of the coal beds over the surface of this rock; and partly to the local fractures and denudations, which the surface has undergone since the original formation of the coal tract: and viewed in this light, the Coalbrook, Canal, and Clashduffe beds may be considered as the same undulated series, partially broken and abrupted near the surface.

§ 188. The Coalbrook, Canal, Clashduffe, and Copper troughs, are traversed by a slip, which ranges nearly north and south, and throws them down fourteen yards on the eastern side. A second, and parallel slip takes place about one thousand yards more to the eastward. And about eight hundred yards beyond this slip, the north-eastern termination of the Coalbrook trough has been found, and coal raised from the outcrops. These slips are vertical fissures, from one and a half to three inches wide, occupied by clay and a leader of coal.

§ 189. Traces of coal have been found also as far as Tullyroan on the north-east, about seven miles from Coalbrook; but this quarter has not been properly explored. The principal workings for coal have been carried on in a superficial manner, at different intervals, between Coalbrook on the north-east, and Killenaule on the south-west, a distance of about five miles; beyond which no colliery has been worked. In this quarter also, smaller basins have occurred in a few instances, included within the larger; a second and upper seam of coal and concomitant beds having been found above the lower. At present little is doing in any part of the district, except on Mr. Langley's estate of Lisnamrock. This field comprehends between four and five hundred acres of coal, the merchantable produce of which would probably exceed one million of tons of coal and culm; an estimate, independent of what might be derived from the workable seam subjacent to that of Coalbrook, or from the coal situated in another estate, lying more to the south-east. It is to be hoped that the spirited proprietor may be enabled to embark a capital sufficient to work his collieries on a scale of magnitude, that would probably be conducive, not more to his own advantage, than to that of the community in general.

§ 190. In the section which I have given Pl. 14, No. 4., I have inserted only the principal and well known upper seams of the successive coal troughs, neglecting the subjacent, as the continuity of the latter throughout the field has not yet been proved, nor have their out-crops on the south been traced; but the question of their continuity might be set at rest by judicious borings, conducted to adequate depths.

§ 191. The Five mile seam varies from fifteen to eighteen inches in thickness. It has been wrought for culm by a long line of pits, particularly along the northern outcrop, but without system.

The Lisnamrock seams are generally from 21 to 27 inches thick, average two feet. The Coalbrook seam, on which the present workings are conducted, yields, from every breast-work of 20 square yards of the seam, three tons of merchantable coal, and from three to three and a half tons of culm, or about 2352 tons of coal and culm per Irish acre. These collieries are well circumstanced in regard to the roof, which is compact and firm; and hence the coal is cut out clean in the broad way, and no pillars are left. As the workmen proceed, rough dry pillars of gritstone are inserted from time to time, and between these are stowed away that portion of the fire clay which is cleared from under the coal, and part of the roof shale which is cut into, in forming the road ways. Hence, whenever the roof settles, it is in large sheets, not partially. The breast-works are always kept clear, and there is no difficulty in ventilation. The coal sells at the pit-mouth for twenty shillings per ton, and the culm for four shillings per barrel of twelve hundred weight, or 6s. 8d. per ton; one half of which price is usually paid to the collier for raising and delivering the coal and culm on the bank, the miner himself bearing the cost of underground stores, hire of labourers, drawing of the coal, &c. The expense of machinery, agency, sinking of pits, &c. falls of course on the proprietor.

§ 192. The general character of the grit rocks, or sandstone of this district, is that of a remarkably close and fine grained compound, hard and firm, consisting of minute grains of quartz with scarcely discernible scales of white mica. It sometimes approaches nearly to the state of a quartzy sandstone, and contains frequent small contemporaneous veins of quartz: and sometimes it includes thin streaks of slate clay. This district seems to be in a great measure deficient in the slaty micaceous sandstone, which abounds so much in parts of the Castlecomer coal district, particularly in the south-eastern quarter, and which affords excellent flags.

§ 193. The fire clay under the coal varies from four to nine feet in thickness. It is of a blackish or bluish grey colour, more or less indurated and tenacious; but on exposure to the atmosphere it soon disintegrates into a powder. Burnt in a strong fire, it becomes white and very hard. The whole substance of the fire clay is, in a manner, interwoven with vegetable impressions, apparently belonging to the grasses; which, when fresh, have a rich, glossy, and almost silky aspect.

§ 194. The coal of all this district, as well as of the other portions of the Leinster coal tract, is wholly of the nature of blind coal (*anthracite*),* with a conchoidal fracture, strong lustre, and thin stratified structure. That of Coalbrook is in general very pure, and seldom contaminated by iron pyrites; and the specific gravity of a pure specimen is 1·61. The fire damp is entirely unknown throughout the Leinster coal tract.

§ 195. At the distance of every forty or fifty yards, the Lisnamrack coal seams are generally interrupted, by what are locally called *hags*, ranging across the troughs in a north-west and south-east direction. These hags are a partial substitution of firm shale in the room of coal, commonly from three to five yards broad, sometimes occupying nearly the whole thickness of the seam, but gradually diminishing and edging out in a north-east and south-west direction, the seam of coal then resuming its usual thickness. Above the hag we may in general perceive in the roof a leader of coal, one or two inches in thickness, and another next to the floor a few inches thick. These enlarge as the hag decreases, until they meet and reconstitute the seam.

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* Glanzkohl of *Werner*; glance-coal, *Jameson*.

§ 196. The roof shale, or slate clay of the coal troughs is of various shades of blackish grey. Immediately above the coal it abounds in vegetable impressions, and it contains flat nodules of clay ironstone for about four feet above the coal. The impressions, when fresh, exhibit a glossy, silky lustre, and evidently consist of thin pellicles of coaly matter, which in some of the larger kinds possess a discernible thickness. On comparing a suite of these specimens with Parkinson's Organic Remains, and with Martin's Petrificata Derbiensia, and on submitting them to the examination of some of my botanical friends, the following analogies were conceived to be established.

Some of the impressions resemble Martin's Pl. 13. fig. 3. (which occurs on the Derbyshire shale, ironstone, and sandstone); and Parkinson's vol. i. Pl. 1. fig. 6. (which occurs on shale), and Pl. 3. fig. 4. (which occurs on sandstone.) These impressions seem referable to the stem of one of the Pines.

Others resemble Martin, Pl. 25. fig. 1. and Pl. 26. fig. 2. (which are both on the Derbyshire sandstone); and Parkinson, vol. i. Pl. 3. fig. 3. (which is on sandstone). The prototypes of these are considered as belonging to the equisetum; but of much larger dimensions than any now known to exist.

Some of the impressions are conceived to be referable to the hippuris, which seem also to bear some analogy to Parkinson, vol. i. Pl. 5. fig. 3. (which is on shale), and fig. 7. (which is on ironstone), and considered by that author as belonging to one of the verticillatæ.

Some other impressions agree with Parkinson, vol. i. Pl. 5. fig. 8. (which is on the coal shale of Haigh in Lancashire).

Delicate impressions, which resemble very nearly the hymenophyllum tunbridgense, also occur, but they are comparatively rare.

The shale displays a great variety of impressions, particularly of such as bear resemblance to ferns, reeds, and grasses, most of the prototypes of which are probably unknown. Some of these present a surface, more than two feet in length, and two, three, or four inches wide. The most numerous impressions of the fern tribe appear referable to the blechnum spicant. Impressions are occasionally found in the clay ironstone also.

The colliers informed me that very rarely small shells were discovered in the roof shale of the Coalbrook seam; and I myself found a few of these reputed shells, displaying a rich glossy smooth surface, and inserted in the shale without order, frequently crossing the laminated structure of the stone. They were, however, very indistinct, and it is doubtful whether they may not be the casts of the seed vessel of a plant, the nucleus sometimes consisting of iron pyrites, and sometimes of shale, while the glossy surface betrays nothing of a calcareous nature. But, on the other hand, the roof shale of the twenty inch seam, below that of Coalbrook, contains very decided impressions of shells; those resembling winged anomiæ being particularly distinct, with the outlines of the shell well displayed. The shells appear to have undergone gradual compression and solution, for the surface represented in the shale is perfectly flat, and in the direction of the laminæ of the stone; but not a trace of the matter of the shell remains.

The late Mr. Tighe notices the occurrence of shells also in the Castlecomer coal shale, which likewise exhibits impressions of ferns.

and other vegetable remains. He remarked impressions very like the polypodium vulgare, a very large equisetum, and the stem, joints, and interior pith of plants resembling the euphorbias.*

§ 197. The top shale of the Lisnamrock coal seams is generally of a lighter colour than that of the roof, and less disposed to shiver and moulder on exposure to the atmosphere. But sometimes it is black, and of the character of drawing slate, or black chalk.

The beds of clay ironstone in the top shale are commonly from one and a half to three inches thick, more or less continuous, and separated from each other by shale three and four feet thick.

§ 198. Vegetable impressions are no doubt to be found in the sandstone of this district also, although I can record only a single observation. I found a loose stone in one of the fields, of the nature of quartzy sandstone, or rather of quartz itself, which presents the same impression as is depicted by Martin, Pl. 11. fig. 1. and Pl. 12. fig. 2, and by Parkinson, vol. i. Pl. 3. fig. 3; which are mentioned by both these authors as occurring likewise on sandstone. The prototypes are conceived to belong to the cacti.

§ 199. In descending the declining surface of this coal district toward the south-east, we find the hollows partly occupied by a deposit of limestone gravel, mixed with debris of sandstone and shale, which gradually increases in thickness as we approach the lower grounds. In this manner, even large boulders of limestone are found in the hollows at the distance of two miles from the limestone flat.

§ 200. The outskirts of the Killenaule coal district consist of three hills, which stand in connexion between Cashel on the south-west and the limestone hollow or valley, which separates this small range from the continuous part of the district on the north-east. The first, next to Cashel, presents limestone on the south-eastern side, conformably supporting shale and sandstone on the north-west. The second consists of limestone in the north-western and south-eastern quarters, but the mass resting upon it seems to be mostly shale, containing some nodules of clay ironstone. The third is limestone, with a south-eastern flank of sandstone, and probably some shale also.

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* Statistical Survey of the County of Kilkenny.

A fourth hill, on which stands New Park, and which borders the small limestone valley below, appears to be wholly composed of limestone.

§ 201. The limestone around the Killenaule coal district is in general bluish grey, or tinged with black, and free from foreign beds, containing only occasionally lydian stone and hornstone. It is arranged in strata, one, two, and three feet thick, in which entrochites are particularly abundant.

IV. *Alluvial Tracts.*

§ 202. That the ocean has been universally diffused over the surface of the globe, no naturalist at present denies. The great point in dispute is, whether the land has been raised from beneath to its present elevation above the water, or the water depressed to its present level below the land. Into this controversy I do not mean to enter.* But it seems impossible to consider the form of any considerable portion of the surface of the earth, or to reflect even upon the nature and disposition of its alluvial tracts, without recognizing the powerful agency of an agitated fluid, in a state of retrocession. The abrupt and curved outlines, the fractured surfaces and denudations of extensive tracts, the sinuosities, glens, defiles, and vallies, the salient and re-entering angles, the plains, all betray its course and moulding force. To ascribe such appearances to a gradual degradation, produced by the influence of the atmosphere and the current of streams, seems to be assuming causes wholly inadequate to such effects. Yet, in our field of observation, the agitation of the fluid in question appears to have been confined within certain limits. The higher parts of the mountain chains exhibit no debris on their flanks, or in the hollows or dells by which these flanks are marked, except such as are of native origin, and referable to the rocks which compose those chains. It is only upon lower levels that we find these debris intermingled with the productions of contiguous tracts; above which, however, those levels are sometimes considerably elevated.

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* I confess, however, my disbelief of a certain expansive power from beneath, to whose operation some philosophers have ascribed the position of the elevated strata of the globe, and have thence described them as *lifted*, or *tilted*. The phenomena recorded in the preceding pages alone, are, to my apprehension, a sufficient refutation of this hypothesis;

§ 203. The flanks of the central part of the Eastern mountain chain are strewed with native debris, and these are dispersed over lower ranges for a distance of some miles from the central group, and sometimes under circumstances that claim particular attention. Cronebane hill bears upon its summit a boulder of granite, (called

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particularly as they respect the relative position of rocky formations, their general and subordinate structure, their inflections, interstratification, and inclusion in each other, and their frequent mutual connexion with those contemporaneous and true veins, by which all rocks are traversed in a greater or less degree. These phenomena seem rather referable to the opposite powers of chemical affinity and mechanical action, under the influence of hydrostatic pressure.

Motty stone), $9\frac{1}{2}$ feet high and 42 feet in circumference; and the sides of the hill are also strewed with boulders of granite, some of which are not much inferior in dimensions.* How then did these attain their present position? The nearest granite rock is that which extends from the eastern bank of the Avonmore toward West Aston hill; but this is very dissimilar in aspect to the granite boulders on Cronebane. The next granite, in point of distance, is that of Ballincarrig on the banks of the Avonbeg; yet in both these instances, (with the exception of West Aston hill itself), the granite rock is found in a situation several hundred feet lower than the summit of Cronebane, which stands nearly upon a level with the bottom of Glenmalur; but the interval between these two places forms at present a curved line, descending from that level until it obtains a depth of nearly seven hundred feet below, at the meeting of the two Avons. May we not conjecture that, as the gradual abrasion and moulding of the surface took place by the operation of a receding fluid, many boulders of rocks might be moved to, and left in a position, which was comparatively level, before that abrasion had been wholly effected? May we not then conceive, that the boulders of granite, scattered over the sides of Cronebane and other hills, were successively lodged in their present position, on lower and lower levels, according as the general surface of the country was progressively moulded into its present form? Perhaps this view of the subject may tend to explain some appearances, upon which I shall have to remark in the sequel. These and analogous phenomena seem to render it not improbable, that the existing form of the surface of the earth may bear but a slight relation to its pristine state, at a time when the universal waters yet prevailed over the surface of the globe.

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* Cronebane (pronounced Cronebawn), signifies *white head*, which, like most of the original Irish names, is distinctive; as the clear white aspect of Mottystone renders it a very conspicuous object to all the surrounding country.

§ 204. The eastern flank of the Eastern mountain chain presents no ingredient of a foreign nature, either in its soil, or in the course of its rivers, until we approach the coast, or the outlets of such vallies as are connected with the sea; but there depositions of limestone gravel and marl prevail. The lines of the Dargle, Glencullen, Glencree, and Glenisloreane streams are, to a certain extent, occupied by such depositions; which encircle the base, and ascend a considerable way up the sides of the neighbouring hills, penetrating into their recesses, and reaching almost to the foot of Powerscourt waterfall. In this quarter, the rising mountains acted as a barrier to their farther progress, but an opening was formed between the two Sugar Loaves, through which the depositions passed to the southward, spreading over the whole of that beautiful amphitheatre, which is bounded by Bray Head on the north and by Wicklow Head on the south, and confined on the west by the range of hills which extend from Great Sugar Loaf, past Newtown, toward Carrigmacreilly. To the west, beyond and above this barrier, no limestone gravel or marl are found on the east of the central chain.

§ 205. Between Wicklow Head and Arklow Rocks, valuable deposits of marl are lodged in all the vales extending toward the sea, but no limestone gravel appears. Thus, if we draw a semicircular line, bounded by Wicklow Head on the north, Kilnamanna and West Aston range on the west, and the Ballinvallow and Glenteigue range on the south, we inclose an area abounding in this excellent manure, which skirts the feet of these hills, surrounds the

Dunganstown range, and occupies the vales of the Three Mile water, the Potter's, and Redcross rivers.

§ 206. Similar depositions are found adjacent to the banks of the Ovoca in the lower part of its course, but in proceeding upward they become less frequent, and disappear altogether at the distance of about five miles from its mouth. The most inland deposit of marl, in this vicinity, occurs near Newbridge on the right bank of the river, and below this, on the left bank, are two other small patches in the demesne of Bally Arthur.

§ 207. Valuable beds of marl, and a few also of limestone gravel, line the eastern and southern coast of the county of Wexford, and penetrate into the vales immediately connected with the sea; yet, as in the county of Wicklow, no where passing the first mountain barrier that arises on the west or on the north.

§ 208. Whence are the limestone gravel and marl derived, which we thus find to be distributed along the coast of the counties of Wicklow and Wexford? The nearest visible limestone rock in the northern quarter, is that which occurs at Williamstown and Bootерstown on the southern side of the Bay of Dublin (§ 165); and to the southward, the first rock of this description that appears, is on the coast south of the town of Wexford (§ 167). If we may draw any inference from analogy, it is probable that the primary rocks of this coast support floetz limestone under the sea, and that this limestone lies nearest to the land, where the debris are found to consist of the coarsest fragments. In the line of the Dargle and between the two Sugar Loaves, large pebbles and even boulders of limestone, twice and thrice the size of the head, occur among the gravel, and are there selected for burning into lime upon the spot.

§ 209. The features of the northern and western declivities of this mountain chain, correspond with these views. The primary rocks are in these quarters almost wholly bounded by the floetz limestone plain; but the debris of the limestone are intermingled with those of the primary substances, and they are distributed over the lower parts of the primary tract rising up the brows of the adjacent hills, penetrating into the vales that flank the central chain on the western side, occupying the inmost recesses, and ascending even a portion of the foot of the central chain itself: debris of this nature may be observed all along the northern brow of the Dublin mountains, accumulated sometimes to the depth of one hundred feet and more; as for instance at the entrance of Glenismaule. These depositions have pierced even through Ballinascorney gap, and through the defile which separates the Tallow from the Rathcool hills, into the narrow vallies in which the Liffey and its tributary streams wind in the early part of their circuitous course. In the same manner, we find the base of the Glen of Imale, and the feet of the adjacent mountains, covered to a considerable depth by depositions of limestone gravel and marl; and the whole course of the valley of the Slaney, from granite through mica slate, and then through the granite flat into the clay slate country to the east, is marked by such deposits, until they gradually diminish to within three miles of Enniscorthy, when the limestone gravel wholly disappears; but the marl continues diffused on both banks for a considerable distance down the river, particularly on the eastern side; yet attaining to heights much above the present course of the stream. The vales of the Barrow, and the Nore, are marked by similar deposits, even after entering into the granite and clay slate tracts. These deposits are generally found on the salient angle of land formed by the bend of these rivers, and their origin is quite evident, since the vallies, in which these streams flow, pass in the upper part of their course wholly through the limestone country; whereas that of the Slaney, on the other hand, touches in no part of its direction upon limestone rock.

It is worthy of observation, that many of these deposits of limestone pebble, gravel, and marl are situated at distances from two to ten miles from the nearest part of the continuous calcareous tract; and at an elevation reaching to 200, 300, and 400 feet higher than the existing surface of the limestone rock itself; as, for instance, in the glen of Imale, and in the upper part of the Aghfarrel stream, the Liffey and King's rivers. The occurrence of debris of red sandstone conglomerate at an elevation considerably higher than the actual fixed position of this rock, is an analogous case, to which I have already adverted in the preceding pages (§ 136).

§ 210. If we examine the borders of the mountain chains on the west and the south, we observe similar relations; and in the vallies which find their outlets in the limestone plain, calcareous debris may be remarked intermingled with those of the mountainous tract, in some cases at the distance of two or three miles from the plain itself, and considerably elevated above it, while higher up they disappear altogether. I have already made a similar observation in the interior of the Killenaule coal district (§ 199); and hence, it is evident that the cause which produced these phenomena was posterior to the formation of all these rocks; since we find the debris of limestone not only resting high up, on the borders of older tracts, but also intermingled with the debris of the newer, and covering in part the more elevated surface of the latter.

§ 211. The limestone field itself abounds in rolled calcareous masses, pebbles, gravel, sand, and marl, often raised into hillocks or long extended ridges; which seem to owe their form to the action of eddies, and opposite currents. There is scarcely any part of the extensive limestone tract that is not more or less marked by them. Sometimes these ridges appear like regular mounds, the work of art, forming a continued line of several miles in extent. That which passes by Maryborough, in the Queen's county, is a remarkable instance of the kind; and similar mounds, hillocks, and ridges occur also in the counties of Meath, Westmeath, Kildare, Carlow, and other portions of the limestone field, in which the calcareous gravel and sand frequently exhibit a stratified disposition, the alternate layers being very distinct from each other.

§ 212. The inequality of surface thus produced seems to have occasioned the formation of those extensive tracts of peat bog, which cover so considerable a portion of the limestone plain of Ireland. The natural course of springs and streams being obstructed, stagnant lakes and pools of water were created, thus promoting the growth of those aquatic mosses and plants, which by their constant successive accretion and decay, appear to compose the mass of the bogs of Ireland. In this manner, it is conceivable that shallow lakes may in process of time have become entirely filled with peat; and that peat bogs may thus have gradually acquired a convexity of surface, or at least that greater declivity by which their borders are distinguished, according to the Reports of the Engineers employed in surveying the bogs of Ireland. The average depth of these bogs is commonly from sixteen to twenty-five feet, but some reach from thirty to thirty-five feet, and the extreme depth observed is forty-seven feet. In the same manner, we may conceive the gradual growth of peat bog to have successively extended from the higher regions to the flanks, and thence to the feet of mountains. That fallen forests were not the primary origin of these peat bogs seems evident from this circumstance, that two and even three successive growths of trees have been observed at different depths in a section of the same bog. In these instances, the trees lie horizontally, frequently crossing each other, and either attached to their roots or broken off; and in the latter case, the stumps usually stand erect where they grew. The prostration of trees, however, may to a certain extent have acted as an auxiliary in promoting the growth of peat bogs. And this prostration appears in general to have taken place, either from natural decay, or from the trees, possessing little hold of a wet spongy soil, having been subverted by storms. This may partly account for trees of all ages being found in the bogs of Ireland, whether these bogs be situated in plains, or form the immediate cover of high mountain tracts.

§ 213. That Ireland was once covered by extensive forests, even in the most elevated chains, can scarcely admit of doubt; for independently of the evidence preserved in the peat bogs themselves of the growth of trees, numerous stools of trunks, long since cut down, yet remain in most of the mountain districts, which require only protection from cattle to produce vigorous shoots. The universal destruction of the forests of Ireland, is principally to be attributed to the general introduction of iron furnaces, as the most profitable mode of consuming the timber, then esteemed a drug of little value; and hence the almost total neglect of copsing those tracts in which the woods had been felled. Remains of the ancient charcoal hearths are still plainly to be distinguished by their verdure and level circular surface, scattered over the rapidly shelving sides of Glendalough, Glenmalur, and other glens, when we look down upon them from a considerable elevation.

§ 214. The marly tracts above mentioned, are distinguished by the remains, occasionally preserved in them, of that remarkable animal, commonly called the Irish elk or moose deer. And the remains of the red deer also have been observed, in one instance in the marl, by the late Mr. Edgworth. There are few of the limestone counties in which the former remains have not been met with. A head and branches are described by Molyneux, measuring ten feet, ten inches, between the extreme tips of the two horns; but they are said to have been found extending even to fourteen feet between the extreme tips. A fine specimen of the head and branches is preserved at Bally Arthur, together with some of the bones of this animal, which were discovered with the remains of several other animals of the same species, in the parish of Castle Ellis in the county of Wexford, about two miles from the sea. They were imbedded in marl at the depth of five feet only, the surface itself consisting of peat to the depth of two feet. Others have been found in the demesne of Johnstown Castle in the same county, in the barony of Iverk in the county of Kilkenny, and on the western side of the county of Wicklow, from whence some of the remains are still preserved at Saundersgrove; so also in the counties of Dublin and Meath; and in many of these cases, it has happened that the remains of several of these creatures have occurred together. The valuable remains of this stately animal preserved in the University of Dublin, contain a greater number and variety of the bones than I have seen in any other collection. But, it is to be lamented that the bones of a complete skeleton have not in any one instance been found assembled together. From what is known, however, there seems little doubt that they belong to a species now wholly extinct, or at least hitherto undiscovered. Should Dr. Stokes succeed in his endeavours to construct a skeleton from scattered members, a subject would be produced in a high degree interesting to the natural historian.*

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* In concluding the account of the mineral constitution of that portion of Ireland which I have described, the English geologist cannot fail being struck by the total absence of that extensive series of formations, which occupy so large a tract in the south-eastern quarter of his own island; and which, in the order of succession, being posterior to the old sandstone, floetz limestone, and coal formations, constitute in themselves more than one well marked era in geology, distinguished by peculiar relations. Of these, however, Ireland is not wholly destitute, as has been shewn in the very valuable Memoir on the North-East of Ireland, by Dr. Berger, the Rev. W. Conybeare, and Professor Buckland, in the third volume of the Geological Transactions.

XIII. *On the Modifications of the primitive Crystal of the Sulphate of Barytes.*

By WILLIAM PHILLIPS, Esq. F. L. S.

MEMBER OF THE GEOLOGICAL SOCIETY.

[Read November 6th, 1818.]

IT is observed by the Abbé Haüy in his "Tableau Comparatif &c." that the crystalline forms of this substance, of which only thirteen varieties had been noticed when his "Traité &c." was published, amount to the number of sixty-three, in consequence of the researches of M. Mabru among the crystals abounding in the departments of the Puy de Dome and Cantal. In my collection there are about 120 varieties of form, of which the greater part are from the north of England.

The primitive crystal, which is a right quadrangular prism with rhomboidal terminations, is subject to several modifications; the varieties delineated by the Abbé Haüy result from various combinations of the planes of eight modifications, with those of the primitive prism; whilst those in my possession result from eighteen. It is impossible even to imagine how many varieties of form may arise from so considerable a number of secondary or modifying planes, when it is considered that the enlargement of the planes of any one modification, may and does often produce in a crystal, so great a difference in general form, from another presenting the same planes, but of different relative size, that the two crystals appear at first sight to have no analogy.* Hence the varieties may be expected to be almost endless.

It is not the object of this paper to describe all the crystalline forms in which I have observed this substance. Its intention is much more limited; being only that of noticing, and delineating the position, on the primitive form, of each of those secondary modifying planes, from the combinations of which have resulted all the numerous varieties which I have seen. I have attempted to measure the angles at which these secondary planes meet with those of the primitive crystal, and with each other, and have in most cases succeeded to a certain extent.

According to Haüy, the relation of the side B of the primitive crystal (Pl. 16. Fig. 1), to the height G or H, is nearly that of 45 to 46.* The accompanying drawing exhibits the primitive crystal according to those proportions, and the planes of each of the 18 modifications on separate figures of less height, which was preferred not only because they more nearly approach the proportions of the crystals, but also because the whole series is thereby exhibited at one view. I have added the representation of a crystal on which the planes of all the modifications are shewn in combination with those of the primitive crystal. This figure (20) is in part imaginary—that is to say, it does not represent any one that has fallen under my notice; but I possess some on which are visible all the modifications delineated on the obtuse angle, except the 6th, and others shewing all those on the acute angle except the 13th and 15th, and nearly in the proportions in which they are relatively drawn. All these crystals, however, are without the 17th and 18th: the former is very common, the latter is very rare.

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* The sulphate of barytes is one among many substances, on the crystals of which it is not common to find the secondary planes equal in respect of size: this is more often observable in those, of which the primitive is a perfect geometrical solid, as the cube, the regular octohedron, &c. than on those which are not; as the varieties of parallelopiped, &c. The secondary planes on the latter do not often present that perfect uniformity, the observation of which on the crystals of certain substances doubtless determined the Abbé Haüy to give each crystal, delineated on the plates to his "Traité &c.", a separate designation. It cannot be denied that the names he has given, are often expressive and sometimes of use, but I am tempted to believe that if that eminent mineralogist had extended his researches to the observation of a number of varieties of form, more nearly approaching their probable limit, the magnitude, and even upon the whole, the inutility of the labour would have become apparent.

Some mode of distinguishing crystals from each other is essential; and as all those planes which form different angles with the faces of the primitive crystal, must be different modifications of that crystal, each resulting from a separate and peculiar decrement, it seems reasonable that this decrement, or the planes which are its consequence, should form the distinctive character. This method, it is true, often places together crystals of a very different general form, arising from the various proportional dimensions of the secondary planes; it nevertheless soon becomes familiar to the observer, whom a little practice enables, if I may so express it, to read off a crystal. It has the primitive planes, together with the 1st, 4th, 7th, and 10th modifications, &c.

I was induced to make a drawing of this, in part, supposititious crystal, from motives of utility. The crystalline forms of the sulphate of barytes, though numerous, may readily be arranged, by the assistance even of the common goniometer, in a series commencing with the primitive crystal, and terminating with those crystals which exhibit the greatest number of planes. In forming such an arrangement, I believe that a reference to this figure will be found of some use, especially if also some attention be given to the annexed tabular view of all the measurements I have been able to obtain.

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* I have heretofore shewn (Geol. Trans. vol. iv. p. 233.) that the measurements of the angles of the primitive crystal by the reflecting goniometer, differ from those given by the Abbé Haüy: hence it is probable that those of the secondary planes, and consequently the height of the prism, which he has deduced from calculation founded upon what appears to be an inaccurate measurement, are inaccurate also.

The crystals of this substance, however, are not ordinarily in the general form of figure 20: the planes of the 12th modification which are situated in the acute angles of the prism, are frequently so large as materially to reduce the size of the plane P and its opposed plane, giving to the crystal a prismatic form in the direction of its shorter axis; and with the planes of the 12th are often associated those of the 4th modification, which are situated on the obtuse angles, both prevailing to such a degree as to give to the crystal the form of an octohedron of which the summits are deeply truncated. The planes of the 1st and 9th modifications also are sometimes very large, and occasionally reduce the crystal to the general form of the cube, exhibiting the planes of several other modifications on the edges and angles.

I have heretofore noticed the fact, that no reliance can be placed on measurements taken by the goniometer on the natural planes of crystals, however brilliant and perfect they may appear, without comparing the results of many attempts. It is even difficult to find two crystals that agree perfectly; they more often vary from one to twenty minutes, so that the following measurements amount only to approximations; but such at least as were made by the assistance of the reflecting goniometer may be considered as being within a few minutes of the truth. But the planes of some of the modifications are almost always rough and without reflection; the measurements of these, therefore, could only be obtained by the aid of the common goniometer, and are denoted by an asterisk: some few are altogether omitted, because that instrument would not assist even in approximating the angle, on account of the minuteness of the planes, as is the case with those of the 7th, 11th, and 15th modifications, which I have observed only on very small crystals.

In conclusion, it may be observed that two motives induced me to offer this communication to the Geological Society. One, that it may assist in arranging the series of crystals; the other, that it may serve as material for the geometrician in the calculation of the precise angles which the planes of the several modifications form with each other and with those of the primitive crystal; the acute angle of the latter, being (according to the reflecting goniometer) 78° 18′, the obtuse 101° 42′, and a lateral or a terminal plane 90°.

Table of Measurements.

			By W. P.	According to Haüy.		
	1 on P	Fig. 2	90° —			
	1 — P′ or P″	— -	140° 50′	140° 46′ 6″	s on M	Pl. xxv. Fig. 110
*	2 — P′ or P″	— 3	166° —	169° 19′ 45″ 30‴	t on M . .	— 117
*	2 — 1	— 20	153° —	151° 26′ 21″	t on s . .	— —
*	2 — 2	— 3	126° —			
	3 — P	— -	121° 55′			
	3 — 1	— 20	148° 10′			
	3 — 3	— 4	116° 25′			
	4 — P	— 5	141° 10′	140° 59′ 21″	d on P . .	— 109
	4 — 1	— 20	128° 50′			
	4 — 3	— -	160° 40′			
	4 — 4	— 5	77 40′	78° 1′ 18″	d on d . .	— 108
	4 — 5	— 20	163° 41′			
*	5 — P	— 6	161° —	162° 2′ 44″	r on P . .	— 114
*	5 — 5	— -	44° 50′			
*	5 — 6	— 20	167° —			
*	6 — P	— 7	173° —			
	9 — P	— 10	90° —	90°	k on P . .	— 115
	9 — P′	— 10	128° 55′	129° 13′ 54″	k on M . .	— 111
*	10 — P′	— 11	160° —			
*	10 — 9	— 20	153° —			
	12 — P	— 13	127° 12′	127° 5′ 13″	o on P . .	— 112
*	12 — 14	— 20	155° —			
	13 — P	— 14	110° 30′			
	13 — P′	— -	141° —			
*	14 — P	— 15	124° —			
	14 — P′	— -	154° —			
*	16 — P	— 17	143° —			
*	16 — P′	— -	126° —			
	17 — P	— -	115° 30′	115° 33′ 8″	2 on P . .	— 118
*	18 — P	— 19	125° 0			

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XIV.—*On the Geology and Mineralogy of Ceylon.*

By JOHN DAVY, M.D. F.R.S.

In a LETTER addressed to Sir JAMES McGREGOR, M.D. &c. &c. &c.
and communicated by him.

[Read December 4th, 1818.]

Kandy, January 26th, 1818.

MY DEAR SIR,

I DO not know how I can better assure you, that I have not forgotten the desire you expressed in the last letter you honoured me with, than by communicating to you the results of my inquiries respecting the geology and mineralogy of this interesting island, hitherto so little investigated.

In a geological point of view, the most general idea that can be formed of the island, according to the best of our knowledge, is, that it is one mass of primitive rock; and unconnected with any other rocky formation, excepting in a slight degree, with one of the newest kind.

The primitive mass of which the island consists rises in the Kandian country, and in the southern part of the island, to a considerable height above the level of the sea, varying from 500 to nearly 7000 feet; an elevation which Adam's Peak, the highest mountain in the island, does not exceed, as I have ascertained by barometrical admeasurement: other parts of the mass, particularly the northern division of the island, are low and plain; and, with the exception of one spot, as far as my knowledge extends, the island in general is surrounded by shelving shores.

The forms of the hills and mountains are not very uniform; most commonly conical and peaked; occasionally craggy and tabular. The direction, too, of the mountain chains, is various.

Every appearance points to great antiquity of formation: few of the mountains exhibit naked rock; the majority of them are covered with debris, and at the base and on the sides of every hill and mountain, there is such an accumulation of alluvium, as clearly proves that the degradation of the heights has been very great. The low country is almost entirely covered with the same kind of debris, insulated rocks being of rare occurrence.

The soil corresponds to the rocks from which it is derived: though almost universally teeming with vegetation in the interior, it is generally poor, and contains but a small proportion of vegetable matter, seldom more than one or two per cent.—proving that the luxuriant vegetation of the country, and particularly of the Kandian country, is more dependent on the high temperature of a tropical sun, and the abundance of water in a mountainous region, than on richness of soil, which is confirmed by the natural sterility of certain parts of the low country that are subject to long continued droughts.

The water, whether of springs or rivers, accords also with the nature of the island: on the coast it is of ordinary purity; amongst the mountains of the interior, it is rarely quite pure; all the water round Kandy, where I have particularly examined it, is of the specific gravity of distilled water, only very slightly impregnated with fixed air, and of such a temperature as it acquires by the influence of the atmosphere and of the bodies with which it comes into contact; spring water being of about the mean annual temperature of the place where it rises. The only exception that I am acquainted with, in regard to temperature, occurs in the neighbourhood of Trincomalie. I must refer to Mr. Cordiner's "Description of Ceylon" for a minute account of the hot wells of Cannia, where the water I allude to is found; merely noticing what I have ascertained concerning their temperature, the nature of the air disengaged, and the nature of the water. Their temperature I found variable, falling when I was at the wells, from 107 to 103, in less than two hours, without any apparent cause; the air which is disengaged from one of them in great abundance, I ascertained by analysis to be azote mixed with a little carbonic acid; and the water itself I found nearly quite pure, containing no earthy or saline matter, and only very slightly impregnated with sulphuretted hydrogen, carbonic acid, and azote.

The vallies are in general narrow and deep, according to the elevation of the hills and mountains by which they are formed. Without a single exception, they have always an outlet, and in consequence of this remarkable circumstance in so large an island, there are no lakes excepting such as have been made for agricultural purposes, by immense, almost incredible, human exertions; or by the effect of the sea, in throwing up sand banks and stopping the natural exit of the waters. Of the former description of lakes, the largest and most remarkable occur in the northern part of the island, where the country at present is almost uninhabited; the latter chiefly on the south-east shore; all the salt lakes in the Mahagam pattoo are of this kind, and derive their salt, as I have ascertained, from the sea, the waves of which occasionally overrun the banks. I mention the circumstance because the formation of salt in these lakes has been considered a mystery by many. Such is a very general description of the leading features of the country. A poet's pen could hardly do justice to its beautiful and sublime scenery. I should wander from my subject were I to indulge my feelings, and endeavour to give a picture of the charms which nature, with a liberal hand, has scattered over this fortunate island; I must confine myself to the mere skeleton, respecting which, allow me to enter into more minute details.

The great mass of rock, of which the island consists, is of two principal kinds; the most prevailing kind is gneiss, the most limited, dolomite.

The gneiss varies in its appearance in different places beyond the power of description; in some places the peculiar structure of this rock is distinct, in others hardly to be traced, and sometimes it disappears altogether; and we find granite, common and graphite, or other varieties of rock, as sienite, common felspar and adularia rock, primitive greenstone, and quartz rock. I shall mention but a few localities; it would be tedious, and perhaps useless at present, to enumerate many.

The peculiar structure of gneiss may be seen in very many places, but no where more beautiful than at Amanapoona, in the Kandian country, where it consists of white felspar and quartz, in a fine crystalline state, with layers of black mica, containing imbedded numerous crystals of light coloured garnet.

A good instance of common granite occurs at Point de Galle, near the fort by the sea side. Graphic granite is rare; I have hitherto found it in one place only, viz. at Trincomalie, where it occurs of a beautiful quality on the sea shore, about half a mile beyond Chapel-point. The quartz in this instance is black or grey rock crystal, and the felspar of a bright flesh colour, highly crystalline; the quartz envelopes, as it were, the felspar, in very thin hexagonal or semi-hexagonal cases; so that nothing can be more different in appearance than the longitudinal and transverse fracture of the rock.

Sienite is not a common variety; however I have met with it in several places; I may mention in particular the neighbourhood of Atgalle and Medda maha novera, both in the Kandian provinces; it occurs rather as a part of another rock, than as a great mountain mass.

Felspar rock is of pretty general occurrence; near Colombo it occurs bluish grey; at Trincomalie of the same colour, and also reddish; and in the neighbourhood of Kandy of a very light brown. Adularia rock is more uncommon; I have only met with it in one place amongst the mountains of Doonberava.

Greenstone highly crystalline, nearly black from the abundance of hornblende it contains, occurs in the neighbourhood of Kandy and Trincomalie, and is one of the rocks of which Adam's peak is composed.

Quartz veins are almost every where common in gneiss; in some places they are so large as to rival mountain masses; of this description is the quartz rock at Trincomalie, where a low hill is entirely composed of it, extending from Chapel-point to the opposite point on which Fort Osnaburgh is built, a distance perhaps of two miles. These quartz rocks stand erect, like denuded veins, very precipitous, and often exhibiting the appearance of buildings in ruin; and hence the name of Chapel-point applied to the termination of the ridge alluded to. The quartz is in general milk white, translucent, full of rents, and very friable, like our annealed glass.

Besides these, the principal, there are other varieties (if I may be allowed the expression) of gneiss rock. I shall mention here only one in particular, in which calcareous spar forms an important ingredient; perhaps the other kinds may be more conveniently considered under the head of imbedded minerals.

The calcareous spar variety occurs in many places, indeed I believe in every one of the many places in which nitre is manufactured in the Kandian country. I have visited two spots of this kind, and I have examined specimens from two more, and on these grounds I have formed my opinion. In relation to this rock, I shall notice only the principal nitre work that I have seen, and which I understand is the most extensive belonging to the natives. It is a large cave in the side of a great precipice, which is situated in the depth of an immense forest surrounded by mountains in a remote part of Doonberava. The cave is about 200 feet deep, and its mouth is about 100 feet high by 80 feet wide. The rock in which it occurs is an intimate mixture of quartz, felspar, calcareous spar, and mica, with here and there talc and some other minerals. Wherever it is exposed to the air, the rock is impregnated with nitre; and not merely at the surface, but as deep as air can penetrate, but no further. Besides nitre, I may remark, the rock contains other salts, as nitrate of lime, sulphate of magnesia, and alum. Were it not foreign to the general account to which I have proposed to confine myself, I could give you further particulars respecting this interesting cave, and respecting the Kandian workmen and their mode of making saltpetre; you would be surprised at the rude apparatus they employ, the degree of skill they shew on some points, and the profound ignorance on others; how they sagaciously add wood ashes to decompose the nitrate of lime, and how, after being at great pains to purify the nitre by picking out the crystals of sulphate of magnesia, they ignorantly throw away this latter salt: nor would you be a little struck by the savage persons of these men, their bodies almost naked, their matted hair and long beards, with minds corresponding to their forms, superstitious in proportion to their ignorance, as is exemplified in their sacrificing to Demons, and offering them their best refined nitre to propitiate favour: but I digress beyond my intention.

The minerals which occur imbedded in gneiss and its rocky varieties amount to a considerable number: in my enumeration of them, I shall mention such only as I have myself found, or know to have been found, in particular places with which I am acquainted.

The only one of a common metal hitherto discovered in gneiss, to the best of my knowledge, is iron. This metal, in different forms, is general, and pretty abundant: I have met with the following species, imbedded in gneiss; iron pyrites, magnetic iron ore, specular iron ore, and red hematite; and bog iron ore, and earthy blue phosphate of iron, of more recent formation. The red hematite and the bog iron ore are the most abundant: it is from these ores that the natives usually obtain the iron which they use. A very faithful account of the process of smelting iron, adopted by the Kandians, is given by Knox in his history of Ceylon. I shall mention only the localities of iron pyrites, magnetic iron ore, and the blue phosphate; the other kinds are generally diffused, and require no notice. Iron pyrites is rare; I have met with it at Ratnapoonaa in Saffragam, disseminated through a rock of grey felspar, and in a vein of quartz on the sea-shore at Mount Lavinia. Magnetic iron ore I have found imbedded in gneiss in the neighbourhood of Kandy, and disseminated through gneiss in the neighbourhood of Trincomalie. The earthy blue phosphate of iron I have procured from marshy ground in the neighbourhood of Colombo, and from a bed of bog iron ore near Atgalli. It is esteemed by the natives, by whom it is used as a pigment.

That other metals have not been found, I may remark, is not from want of enquiry. Wherever I have been, I have sought more particularly for tin and copper, but in vain. I have never seen the slightest traces of either, or of lead. It is asserted in some publications, and those of recent date, that gold and mercury are found in Ceylon. The result of my enquiries is, that this assertion is completely erroneous.

The poverty of the island in metals is not less remarkable than its richness in rare and valuable minerals. Most of the gems for which Ceylon is well known, were originally, I believe, imbedded in gneiss; I say 'believe,' because as these precious stones are seldom found in their native rock, we cannot say with certainty whence they are derived, but only conjecture whence, from the quality of the alluvium in which they are met with, and from the nature of the rocks adjoining.

The minerals which I have discovered in gneiss, or believe to have been at one time contained in this rock, are the following:

1. Belonging to the quartz family, I may enumerate quartz, iron-flint, and hyalite. Ceylon affords all the different variations of quartz, as rock crystal, amethyst, rose quartz, cat's-eye, and prase, and I need not repeat, common quartz. Rock crystal occurs in great abundance, both massive and crystallized, of various colours, good quality, and in large masses. It is so common, particularly in the Kandian country, that its localities do not require to be noticed. The natives use it instead of glass in making spectacles; they employ it, too, for ornamental purposes, and in statuary; there is a small well executed crystal figure of their god Booddo, in the great temple in Kandy. Amethyst also is abundant; very beautiful specimens of this mineral are found in the alluvium derived from the decomposition of gneiss in Saffragam and other parts of the Kandian country. Rose quartz, which is common, is found, I believe, in the same ground as amethyst. Ceylon is remarkable for producing the finest cat's-eyes in the world. The best specimens of this singular mineral, that I have seen, have been found in the

gneiss alluvion in Saffragam and Matura. Prase is a variety of quartz that is not common in the island; I have only met with it among the pebbles on the sea shore at Trincomalie. The second species of quartz, iron-flint, is not uncommon in the Kandian country; it is found in the beds of rivers, in the state of rolled masses: I believe it to be a vein-stone. The Kandians apply it to all the ordinary purposes for which common flint is used by us. The third species, hyalite, is very rare indeed; I have met with it only in one place, viz. in the great Nitre cave in Doomberawa; it incrusts a rock; it very closely resembles the siliceous deposition about the great Geyser, and is a hydrat of silica.

2. Belonging to the schorl family, I am acquainted only with two species that undoubtedly occur in Ceylon, and which are topaz and schorl. Topaz commonly passes here under the name of white sapphire: it is generally white, or very pale blue or yellow. It is found in gneiss alluvion. Schorl I have not found in that abundance which I expected; common schorl is not indeed uncommon; I have in many places met with it in gneiss, but tourmaline is rare: the honey-yellow variety is the only one I have seen, and I have not yet ascertained its locality. I may mention, that it is believed by some that both the emerald and beryl occur in Ceylon: I doubt it. Most of the dealers deny the occurrence of the former, and I have not met with an individual who can say he has found a beryl. I am disposed to believe that all the beryls which are sold here, as well as the emeralds, are imported.

3. Of the garnet family, three species occur in gneiss, which I have found in this rock, viz. the garnet, pyrope, and cinnamon-stone. The common garnet is very abundantly disseminated through gneiss in almost every part of the country; the crystals are in general indistinct, small, contain a large proportion of iron,

and are very apt to decompose: the best and most perfect crystals of this mineral, that I have met with, has been at Trincomalie, in quartz rock. The precious garnet occurs but in a few places, and I have not yet seen it of good quality; at Trincomalie it is contained in hornblende rock. Pyrope is comparatively rare: I have met with a small quantity of it in decomposing gneiss at Matura. Cinnamon-stone, though an abundant mineral in this island, to which it is peculiar, is found in few places only; indeed I can mention only two localities with certainty—Cotta, where it is found in small irregularly shaped masses in gneiss alluvion, and near Belligam, where it enters into the composition of a large detached rock, with felspar, quartz, hornblende, and graphite, which are the other constituent parts. The thick wood, round the spot where this interesting rock occurs, prevented me from examining the adjacent country. From what I saw, I was inclined to suppose the rock a part of a vein, and that it had rolled down from higher ground, the nearest rocks to it consisted chiefly of gneiss or felspar. I may here mention, that there is a doubtful kind of cinnamon stone, which occurs in many places, as in the gneiss at Colombo, Mount Lavinia, Dodrah head, &c.; it is disseminated in very small masses, has the fracture and lustre of cinnamon stone, is semitransparent, and never crystallized: it certainly belongs to the garnet family; I am disposed to consider it merely as a variety of cinnamon stone, from which it appears to me to differ only in being of a redder hue, and in this respect approaching pyrope.

4. The zircon family is certainly more numerous in Ceylon than in any other part of the world. As far as my knowledge extends, it is confined to the districts of Matura and Saffragam: it is most abundant, I believe, in the former, as is indicated by the popular name, "Matura Diamond," which is applied to the finest varieties of zircon by the dealers in gems. Besides the two well established species,

common zircon and hyacinth, I have met with a third, massive, opaque, and uncrystallized, and of a dark brown colour. I have specimens of it weighing two or three ounces from Saffragam. I may notice another mineral from the same part of the country, which appears to me to belong to this family; it is black, opaque, of small conchoidal fracture, and vitro-resinous lustre, hard, of high specific gravity, in general amorphous, rarely crystallized, the crystals imperfectly formed four-sided prisms terminated by four-sided pyramids; I describe from memory, my specimens being at Colombo. The natives, I need not say, are completely ignorant of the true nature of zircon: the yellow varieties are sold as a peculiar kind of topaz; the green as tourmaline; the hyacinth red as ruby; and the very light grey as diamonds. All the varieties that are brought into the market are found in the beds of rivers, or in alluvial ground. Both in Saffragam and Matura the nature of the alluvion is the same; it is derived from the decomposition of gneiss rock. Near the fort of Matura, where I saw several specimens of this mineral found, the alluvion consisted of quartz and clay, with mica and graphite, and some other minerals disseminated through it. The only places where I have discovered zircon in its natural situation, are, a small island in Belligam bay belonging to the district of Matura, and a few miles from Belligam, on the way to Galla. On the former spot, it is sparingly disseminated through a rock consisting chiefly of quartz and schorl. At the latter it occurs abundantly in a rock composed of quartz and adularia: the zircon in some parts of the mass is in so large a proportion, that the rock almost deserves the name of the zircon rock. The mineral in this instance is crystalline, and most commonly green or brown; the rock is remarkable for its specific gravity and the resinous lustre of its fracture.

5. Ceylon is celebrated for spinell, sapphire, and corundum. They occur here, I believe, in gneiss. Spinell is comparatively rare; I have got a few small and beautiful crystals of it, which were said to have been found in the Kandian country; and I have detected it in specimens of clay iron ore from a part of the interior, where gneiss is the only rock.

Sapphire is much more common; it occurs in the gneiss alluvion of Matura and Saffragam, and in the neighbourhood of Arisahaville and Ruanwelle. Hitherto I have searched in vain for it in the rocks surrounding the places in which it is found. All the varieties of sapphire occur in perfection in this island, as the blue, red, yellow, green, white and star stone; and in the places already mentioned. The green sapphire is very rare; the only specimen that I have seen of it appeared to owe its colour to the blending of blue and yellow.

Corundum is less frequently met with than the sapphire. I know of one place only where it abounds in the island; it is a spot called Battagamunna, near Atala in the province of Uwa. It is collected and brought to Kandy as an article of revenue; the specimens of it I have examined are either irregular masses, or crystallized in the form of low six-sided prisms. I have not yet been into Uwa; but from the specimens of rocks that I have procured from that quarter, and from all the information I can collect, I have little or no doubt that the matrix of this mineral is gneiss, on a granite rock.

I may observe that Ceylon affords specimens indicating a gradation between sapphire and corundum. The chrysoberyl is said on good authority to occur in the sand of rivers in this island: I have no doubt of the fact, but hitherto I have not met with the mineral.

6. Of the felspar family, I think it likely several species may

exist in the island. I have found all its sub-species, viz. adularia including glassy felspar, Labradore felspar, common felspar, and compact felspar. All these sub-species are common in gneiss, with the exception of Labradore stone, which is very rare; I have only met with it at Trincomalie, in graphite granite.

7. Of the hornblende family I am only acquainted with two species that occur here, common hornblende and glassy tremolite. The former is pretty abundant, entering, as it has been already observed, into the composition of rock; the latter is rare: I have found it only at Trincomalie, in a narrow vein in gneiss.

8. Pitch stone is the only mineral of the family of this name that I have yet seen in Ceylon: near Trincomalie I discovered it in a small vein in granite, and I have observed it no where else.

9. Mica, as an ingredient of gneiss, is of course abundant; besides, it often occurs in large plates imbedded in this rock. Common chlorite is to be met with occasionally: at Trincomalie I have found it disseminated through quartz.

10. Talc is rare; the only place where I have yet observed it is in the Nitre cave at Doomberawa.

11. Calc-spar and anhydrite are the only calcareous minerals that I have hitherto discovered in gneiss, with the exception of dolomite. I met with both the preceding minerals finely crystallized, in the Nitre cave before alluded to.

12. Belonging to the inflammable class of minerals, I have found only one, viz. graphite, which is pretty commonly disseminated in minute scales through gneiss. It occasionally occurs imbedded in this rock in small masses. It is worthy of remark that graphite is generally found in company with gems. I have had so often occasion to make the observation, that now I never see the former without suspecting the presence of the latter.

It has been asserted that sulphur is found in Ceylon; but from all the information that I can collect on the subject, it would appear to have been asserted erroneously. There is good reason to believe that the sulphur formerly employed by the Kandians in the manufacture of gunpowder was secretly procured from the continent of India, by means of pilgrims going to Adam's Peak.

Having now briefly considered the gneiss rock of the island, its varieties and imbedded minerals, as far as I am acquainted with them, allow me to call your attention to the other primitive rock, viz. dolomite rock.

The only parts of the country where I have seen this rock forming hills, is in Matele, a province between Kandy and Trincomalie, and in the neighbourhood of Hangran ketty, which is a few miles to the east of Kandy. In Matele it appears to be the prevailing rock; near Hangran ketty it only composes one hill. Besides occurring in mountain masses, dolomite is found in veins. In this form I have met with it in Saffragam, Doomberawa, and in the immediate neighbourhood of Kandy. The hills composed of it which I had an opportunity of examining, are low, steep, and rather conical. In Matele I saw at a distance higher and bolder hills, some of them of very singular shape, which I suspected to be similarly constituted; but I could not ascertain if they were, the country being uninhabited and very difficult of access, and my time limited. The dolomite of the hills I examined is pretty uniform in its nature and appearance; where exposed to the air, it is rendered black by a minute lichen with which it is covered: internally, it is either snow white or greyish white. It is rarely fine granular, generally crystalline, and in a few places highly crystalline, being composed of rhombs that are easily separated by a blow. Judging from the variable hardness of different specimens, and the action of acids, the proportions of the constituent parts of the rock must be variable in different instances, the harder kinds abounding most in carbonat of magnesia, and the softer in carbonat of lime.

The only metal that I have hitherto detected in dolomite is iron, in the form of iron pyrites.

The only minerals that I have discovered disseminated through it are the following: mica; apatite; a bright yellow mineral, which I am disposed to consider a variety of cinnamon stone, as it resembles cinnamon stone in all its essential properties; white clay, apparently derived from the decomposition of felspar; graphite, and ceylanite. Mica is pretty common in dolomite; generally of a straw colour, semitransparent, and in six-sided prisms. Apatite is rather less common; it is either blue or green, and not distinctly crystallized. The mineral which I conceive to be a new variety of cinnamon stone, I have found in the neighbourhood of Kandy, disseminated in a large vein of dolomite. Clay in dolomite is of rare occurrence. Graphite is often to be seen scattered through it in very minute scales. Ceylanite is more abundant in dolomite rock than any of the preceding minerals, and more generally disseminated through it. It occurs crystallized and amorphous, of various colours, bright, azure blue resembling the blue sapphire, violet, pink red, grey and white: its crystals are generally small and very small. I have found the fine sapphire blue variety only at Nalandi; the other varieties occur in the neighbourhood of Kandy, and in a vein of dolomite not far from Ratnapoma in Saffragam.

Connected with this rock, from which they are derived, I may mention three other minerals, calc-sinter, calc-tuff, and agaric-mineral. I have met with calc-sinter superimposed on dolomite at and beyond Naland. Calc-tuff is of common occurrence at a place called Pulzan Cadarette, and between this place and Trincomalie, in the channels of rivers, which flow only during the rainy season, and are dried up soon after this season is passed. Agaric-mineral I have met with in small quantity between Kandy and Hangranketty.

The only remaining feature that I am acquainted with in the geology of Ceylon, not yet considered, is the recent formation of rock before alluded to that occurs on the shores of the island. It is sandstone rock, which has formed in many places below high water mark, extensive horizontal beds: the rock is in general hard and compact, of a light yellow or grey colour. It consists of siliceous sand and minute fragments of shell. Submitted to chemical analysis, its constituent parts appear to be the same as those of the sand of the contiguous shore, and their proportional quantities similar. What the cementing principle is I have not ascertained; there is no reason to consider it iron: in all probability it is the same as that of a similar formation in the west of Cornwall. It is remarkable, that this rock does not form in sheltered situations; on the contrary, where the sea breaks with uncommon violence. From the composition of the rock and its situation, there is good reason to believe, not only that it is very recent, but that the process of consolidation is still going on. How far this sandstone formation extends along the shore I have not yet been able to determine; I have found it near Colombo, at Negombo, and in many places between Point de Galle and Matura: further, I have seen specimens of a similar rock from the northern shores of the island.

I have been asked often, "are there no volcanic remains, or indications of volcanic action in Ceylon?" I have sought for them, but hitherto without success. Trincomalie is the only part of the island that I have yet seen that excites even the suspicion of volcanic action. I have mentioned one circumstance that may lead to this suspicion, viz. the hot-wells of Cannia; and I have alluded to another, which is striking at Trincomalie, viz. the peculiarities of the bay and shores; the bay, very near land, being unfathomable in many places, and the shores in general very precipitous, whilst the surrounding land is comparatively low. But these phenomena are very slight indications of the action in question, and I am not aware that there are any other.

I will not extend this long letter farther by any comments on the geological and mineralogical peculiarities of the island; they are striking, and speak for themselves.

I have the honor to be,
My dear Sir,
Your very obedient humble Servant,

J. DAVY.

XV. *Remarks on the Geology of the Country between Tellicherry and Madras.*

By BENJAMIN BABINGTON, Esq.

OF THE HONORABLE EAST INDIA COMPANY'S SERVICE, MADRAS.

Communicated by WILLIAM BABINGTON, M.D.

[Read 15th January, 1819.]

THE road between Calicut and Tellicherry runs near the sea all the way, but seldom affords a view of it.

Comparing this country with the Carnatic near the sea, it is infinitely more fertile and populous; and where the land is not cultivated, the bushes and grass are greener. The villages are composed of huts not built close together, but each is in its own enclosure, which is separated from the next, not only by a fence, but by a very deep narrow lane. The commonest trees are cocoanuts and arekas,* which are the most valuable production of the coast. Jack trees,† and a kind of slender banian,‡ are also much cultivated; while innumerable forest trees spring up spontaneously, round all of which the pepper vine is seen winding its graceful tendrils, and climbing almost to their tops. The Malabar huts are remarkably neat: the thatch is thick, and the eaves come very low, to keep the violent rains of this coast from the walls, which are merely composed of mud. The Hindoo inhabitants, of both sexes, wear no clothes above the waist, but the Maplar women wear a loose short shift over their petticoat, not unlike that worn by the Arabs, their ancestors.

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* Betle nuts, Areca Catechu, *Linn.* † Artocarpus integrifolia, *Linn.* ‡ Ficus?

The face of the country in general below the Ghauts is hilly. These hills are low, of a rounded form, and composed of the ferruginous stone so peculiar to India, called by Buchanan laterite. In this porous rock, the red ochry part is the matrix, and the kidney shaped interstices are filled with white earth: the whole is alluvial, being formed from the washings of the Ghaut mountains. In these, the hornblende uniformly decays into a red oxyd, and the felspar into porcelain earth. Why these are aggregated in their present form, the red particles forming the matrix, the white the kidneys, I cannot explain. Whenever the alluvial rock, thus formed, is exposed, the white parts are washed away, and a porous ferruginous stone is left behind. Such is the general formation of Malabar. The primitive rocks underneath possibly appear in many places above this coast: I know them to do so, at a place about midway between Calicut and Tellicherry, at Moy, and at Tellicherry. Four or five miles inland from Calicut, there are two low hills, composed of cubic iron ore.* These are probably in beds in the primitive rock of the country, though I could perceive nothing but the laterite around. From Tillicherry, the laterite forms the hills, until you arrive at the foot of the Ghauts, which mountains are composed in general of a compound rock, which I call gneiss, though in some places quartz is intermixed with mica. The mountains formed by this rock, and which line the western side of India, are not of very rugged outline; on the contrary, they are in general wooded to the top: they are very high. Bannason hill, which is among the highest, is said to be 7000 feet above the sea. This rock is every where in strata highly inclined, almost vertical. It has in some places more quartz, in some more felspar, in some more hornblende; thus varying in colour, and aggregating in streaks. Further on, between Peria and Manantoddy, it contains much precious garnet, and is exceedingly tough. In its decay it becomes of an ochry red. Near Manantoddy, there is no fresh exposition of rock: there is indeed a quarry of laterite, about a quarter of a mile from the hill, on the old Madras road. It is worked close to the surface, and the workmen seem never to cut down beyond the depth of a few feet. The instrument used is an axe, for the rock is of a consistence between stone and clay when fresh. This axe is of the annexed shape.

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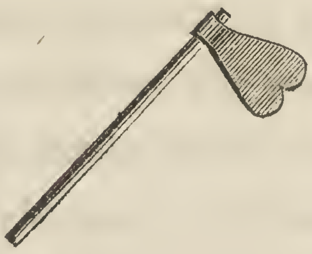
* This iron ore, though it has been occasionally worked by itinerant artisans, is now not used. It appears to be very rich, and I have understood contains 75 per cent. of iron. It is sometimes mixed with a green crystallized mineral, which is probably hornblende; and with another substance, which resembles bronzite in colour, but is probably the preceding mineral in a state of decomposition.



Perhaps two points of contact are less apt to break the stone than one. When the workman has chopped away at the four sides and made the stone flat at the top, he makes a cut or two horizontally underneath, and the mass immediately splits in that direction. The stage from Manantoddy to Bavally Nulla is very hilly, but the hills are never steep; their composition, however, changes from the greenstone above mentioned, to a rock of a small wavy texture, which appears to be chlorite slate. There are also fragments of a compact dark grey rock, with viens of sienite running through it. The soil is now no longer ferruginous, but a black mould, and where rain has fallen, a black mud. This soil, in general, covers the rock so completely, that it is difficult to gain a sight of it, and it is never exposed but in small nodules or fragments, by which one cannot judge how it lies. Close to Bavolly hullah, rock to the extent of many feet appears above the surface, and this is reddish sienite. As we advance beyond Bavally hullah, this sienite gathers more and more hornblende, and when become quite a dark rock, it is intersected by veins of light sienite. Here, also, are seen among the sienite, masses and perhaps strata of compact basaltic rock. Portions of felspar lie on the surface, as well as quartz. This latter I had observed further back, disseminated like flint in chalk, through the decayed fragments and mould, of which the surface of the greenstone mountains above was composed. I may observe, that these fragments, and wherever the rock had been cut away to form the road, split in angular and generally rhomboidal masses. Between Bavally hullah and Antersuntah, wherever the rain had formed channels, glittering black sand, like that smelted at Chittoor, and which will be alluded to hereafter, was deposited. The whole of the country between Canute and Antersuntah, is one continued forest with underwood, and it has been so time out of mind. Though one of the most beautiful countries in the world, yet it is unfavourable to geological observation, because the rock is seldom exposed. Between Kakuncottah and Antersuntah, the first rocks I met with, about four miles from the former place, were of green compact felspar coloured by hornblende: a hundred yards further, I came to a block, which I take to be cyanite and garnet. Here was also greenstone and hornblende. These rocks we came to previously to arriving at the village of Kairapoorah. All the rock between this village and Antersuntah is greenstone, with what seems compact felspar. Whether the latter is all in veins, or whether mixing with the greenstone in strata, I cannot tell: from its quantity, (for it is lying in abundance on the surface in many parts of the road), I should think the latter. From Antersuntah to Humpapoor, a distance of seventeen miles, I made no observation, as I travelled in the middle of the night. The jungle now becomes lower, and the bamboo clumps disappear: it is therefore no longer fit shelter for elephants. The hills become lower as you recede from the forests, and the soil changes to a red hue, from the black, which seems to be decayed vegetable matter mixed with the charcoal of parts of the forests that have been burned.

From Humpapoor to Chittunhully, the road runs over low waving hills, covered in most places with high bushes. The rock is exposed above the surface in many places; in the first part of the stage, it is deposited in layers almost perpendicular, and dipping towards the south-west. It is impossible to follow the alternations of these layers. In one place I observed a layer of quartz, then another of greenstone, then one of quartz, then one of lapis ollaris. This last is the most abundant rock in this stage, and is sometimes more talcose than at others. Some of these layers, both of quartz, greenstone, and lapis ollaris, are several feet thick. Between Cheltunhully and Mysore, the ground is strewed every where with angular pieces of quartz, greenstone, or lapis ollaris. The quartz is sometimes of a red hue. It is remarkable, that although when broken with a hammer it has a vitreous fracture, the action of the air seems to decompose it angularly; it assumes also a horny appearance. The rock, in situ, at an exposition of it about the middle of this stage, seems a stratified mixture of granular quartz and hornblende; further on, pure hornblende appears, and within three miles of Mysore, an extensive stony plain is passed over, consisting chiefly of small fragments of the rocks already mentioned, but also of small irregular masses, of what, from its weight, I take to be a very pure magnetic iron. The compass within which this ore is found strewed does not exceed a few miles; probably some vein or bed runs through the rock below. From Mysore to beyond Muddoor I travelled at night, but from this to Chinnapatam, the rocks begin to assume that variegated appearance, which a mixture, sometimes in masses, but generally in contorted layers of hornblende, quartz, mica and felspar produces. A little before arrival at Closepetta, a rock juts up by the side of the road, which, though not above two or three yards broad, contains perhaps a hundred of these alternations, some so distinct as to be called veins of quartz; others differing but slightly in colour from the layer next them: some parts of this rock contain garnet. In general, these strata are very much inclined, but some are twisted into numerous serpentine directions. As we advance beyond Closepetta, the hills close near us. These are all very abrupt and perpendicular, though with rounded tops; their sides do not present sharp ridges and furrows; they are of a smooth form, but too steep to admit of the formation of a soil. I took specimens from immense fragments and boulders near their feet; and these were all of a coarse sienite, in which the crystals of felspar were very large, and the hornblende distinct. The former was generally of a reddish hue, but it was sometimes white, and passed with the hornblende into a greenstone, while through this again, veins of quartz ran. In the variegated rock mentioned above, whole masses of hornblende were visible. I am inclined to think that all the high mountains of Mysore are of this sienite,* and that the variegated rock will be found at a lower level. There had been much rain, and in all the little channels in the road there was a deposit of bluish black sparkling sand, which did not intermix with the white sand or red soil: this is the same as that smelted at Chittoor for iron. All the black rock which I have seen in Mysore, is hornblende, more or less perfectly crystallized, passing sometimes into basalt. The rocks continue of the same nature as those last described beyond Biddidy, and within a few miles of Bangalore, where there is a most remarkable exposition of their irregular veined appearance: no marble was ever more so. In many places on the road the soil appears to some depth; it is red, and frequently covers large heaps and masses of decaying and decayed felspar. Quartz fragments, many of a red colour, are also very numerous on the surface.

From Bangalore to Ooscotta I travelled at night, and beyond this place there is no appearance of rock, the country being high open land, as it is all about Bangalore. The first rocks that appear are nearly midway between Ooscotta and Norsapoor: they are low rounded masses, pushing but little above the surface of the ground, and are composed of felspar and hornblende rather intimately mixed. At Nursapoor, low rugged mountains appear, the sides of which are covered with masses, so that they seem rather gigantic heaps of stones than natural rocks. The most of these rocks are the compound of felspar and hornblende mentioned above, but they begin here to be veined, and to contain masses of a dark rock which is probably inclining to basalt. It is in truth little different from hornblende, for we have a series from the most crystallized to the earthy fractured rock. When the surrounding matrix decomposes, which it does more readily than these contained masses, they become exposed on the surface of the ground, retaining more or less the shape they had taken when imbedded, and rounded more or less by weather. They seem all to have a tendency to split in concentric layers, but are exceedingly tough. They are the masses I have mentioned as basalt in former journeys. I remember to have seen at one corner near the base of the upright obelisk called Cleopatra's needle, an imbedded portion of black rock of the kind I am now describing: perhaps they are common in sienitic rocks; they certainly are so in India. This black stone is that used by the natives in all the finer kinds of sculpture: all their idols are carved in it, the most beautiful of the stone ornaments at Congeveram, and the pillars forming the verandah of Tippoo's tomb at Seringapatam. From the peculiarly sharp and unbroken edge of its angles, its durability and hardness, it is well adapted to sculpture. The natives sometimes give it a high polish, and greatly increase its blackness by oil. The country as you proceed from Colar is open, and only here and there a few rocks are seen above the surface: these seem more compact and less veined as we advance, which is proved by the few stones and fragments covering the ground. The dark rock especially is close grained. The rocks however do not otherwise differ in their nature. Low mountains are seen in front, which stand on the borders of the eastern Ghauts. The mountains in the highland of Mysore are not in general very high, on the average perhaps not more than 700 feet. They are rugged and stony, of a longish form and generally barren: this applies rather to the country east of Bangalore than to the west. They do not lie in lengthened ranges, but two or three are near each other, and then the land is clear between, except from low rocks here and there. These rocks, especially on the east side, are frequently in sloping ledges, and some of the mountains themselves have steep sloping ledges also. Their decay leaves a whitish soil beneath the surface, I suppose from the quantity of felspar they contain. The dark particles of hornblende become ferruginous, and this is in general the top of the soil, which is reddish. Little fragments also become rounded, and in some cases, as at Bangalore, the whole is settled into the ferruginous stone mentioned as seen on the Malabar coast. In the detritus of these rocks, it does not seem that particles of felspar are washed away until they are decomposed; on the contrary, water seems to percolate through the mass, and carry off the other constituents of the sienite, leaving the felspar in a decayed state in mass. Between Tompelly and Moolwagul there is much decayed rock. From Moolwagul to the top of the Moogly pass I travelled at night. This pass, down to the Carnatic, consists chiefly of a chain of wooded mountains, which run northerly and southerly; and though the road passes up and down these for some miles before arrival at the lower land of the Carnatic, yet there is not a decided and continued descent except in one place. The rocks which compose these mountains I omitted to write a description of on the spot, so that they will be best known by an inspection of the specimens collected. The country below continues nearly as rocky as above: the low mountains run far beyond Chittoor into the interior, and rocks push up every where above the surface. Two great divisions of the rocks still continue, the one being the greenstone with a vein of quartz, the other the black rock. This latter, being found in particular places sticking up in blocks above the surface, I am led to believe runs sometimes in dykes or lies in beds. This seems of a more harsh feel than that which is found imbedded in the sienite, and it tends to split angularly, not concentrically. The composition of the mountains in the neighbourhood of Chittoor may be known by inspecting the specimens. On these I can only remark, that different parts of the mountains are composed of the different varieties of sienite apparently casually, and that the dark rock is in imbedded masses. From Chittoor to Arcot, the road in one place passes near a mountain which is of the same nature as those of Chittoor, only much decayed. White rock is seen on the surface in this stage, and the usual rocks here and there jut up above the surface. As we advance into the Carnatic from Arcot, there are no mountains seen to the eastward nearer than those of the Mount and Sadros, but rocks are seen in many places pushing through the soil, which though some of them having veins shew no signs of stratification, are of a more vitreous and intimately mixed rock, varying in colour, but usually pretty dark. This rock seems to be the chief one in the Carnatic, and it is uniform in its composition.

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* Dr. Heyne also observes (Tracts on India, p. 42) that the inland range of the Ghauts is composed of sienite as well as the eastern Ghauts, differing but in the colour and proportion of felspar.

In order to complete this very imperfect outline of the geology of a line drawn from the Malabar coast at Tellicherry eastward to Madras, I may observe that the flat form of the Carnatic, that is, of all the country east of the eastern Ghauts of Mysore, leads to the notion that at some former period this track of country was covered by the ocean. In confirmation of this hypothesis are the following remarks, which the digging of a well in Colonel Marshall's garden, about two miles from the sea shore at Madras, afforded me the opportunity of making. From the surface for five feet there is a stratum of brown clay, chiefly intermixed with sand. Then follows a stratum of blueish black clay, in which, at the distance of 21 feet, there is a thin and scattered layer of large oyster shells which all lie in a horizontal position, and into the lamina composing the shell the black clay has penetrated, so that they split asunder with great facility. There are also shells of the cockle, and other kinds. At the depth of 27 feet the springs of water begin to gush; the stratum becomes softer, and more and more mixed with siliceous sand, still however of a dark slate-black colour. This continues to 37 feet, the lowest point to which the well was dug, when lumps of what I suppose to be green martial earth were found intermixed with sand.

In order to give a notion of the level of the peninsula from east to west, in the line which I have followed, I subjoin a list of barometrical heights. These I took at most stages both going from Madras to Callicat and returning; and I have in such places given the result of both observations. The reason they sometimes differ so much may be a change in the atmosphere between the observations, which I had not the opportunity of correcting by the usual means. I merely took an observation at one place, and then at the next perhaps 15 miles off, and no allowance is made for difference of temperature. Wherever there was a rapid ascent or descent, so that not much time elapsed between the observations, as for instance in mounting the western Ghauts, my barometrical observations taken at different times agreed very well. It is remarkable, too, that the average heights up to Bangalore, summed up, give the same result within a very few feet, as is stated in Arrowsmith's map of India to have been obtained by Major Lambton. They are probably therefore pretty correct.

	Observ. going.	Average.	Returning.
Arcot above Madras	626	624½	623
Chittoor above Arcot	512	432½	353
Moogly above Chittoor	585	578½	572
Pullamauery above Moogly	568	579	590
Nungily above Pullamauery	128	116	104
Moolwagul above Nungily	498	437½	467
Colar above Moolwagul	+57	—3½	—64
Nursapoor below Colar	—23	+26	—75
Ooscottah above Nursapoor	+81	+14	—53
Bangalore below Ooscottah	—30	+70	+170
Biddidy below Bangalore	474	530	586
Chinnapatam below Biddidy		333	
Seringapatam above Chinnapatam		38	
Mysore above Seringapatam		283	
Antersuntay below Mysore		5	
Bavally Nulla above Antersuntay		44	
Manautoddy above Bavally Nulla		314	
Peria below Manautoddy	79	159	239
Top of Ghaut above Peria	211	251	291
Midway hut below top of Ghaut	992	973½	955
Bottom of Ghaut below Midway hut	1327	1320½	1314
Mr. Dyer's House, Tillicherry, below bottom of Ghaut	259	329½	400
The Sea below Mr. Dyer's House		119	
Malabar Sea below Bangalore	2839¾	2698	2981
Differs from Lambton	—69	—210	+73

Note. The marks of + and — are placed where by one observation a place was above another, and by another below it. Where only one observation was taken, the result is placed under the head Average.

	Lambton.	Mine going.	Average.	Returning.
Bangalore above the Coromandel Sea	2908	2912	2878	2926
		4	30	18

XVI.—*Description of the Rapids of Imatra, on the Voxa River, in Carelia; with an Outline of the probable History of their Formation; and a Notice of the Bursting of the Lake Souvando into the Ladoga, in the year* 1818.

By The Hon. W. T. H. F. STRANGWAYS.

MEMBER OF THE GEOLOGICAL SOCIETY.

[Read February 19, 1819.]

THE falls, or more properly the rapids, of Imatra, situated in Carelia, on the north-west of Petersburgh, are formed by the sudden contraction of the channel of the river Voxa, about six versts below its outlet from the lake Saima, and three from the post station of Sitola, where the road from Viborg joins that from Wilmanstrand to Kexholm.*

The Voxa, which is of a considerable size above and below the rapids, is, for the space of half a verst,† confined within a rocky bed of about sixty feet in breadth. The western bank is a high rocky ridge covered with wood; the eastern a bare rocky wall, in some places considerably overhanging the river. This east bank is the perpendicular section of a platform, or table land, which extends to the foot of the hills on that side of the valley: these hills extend north and south parallel to those of the western bank, and are of equal height.

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* Plate xvii.

† One hundred and four Russian versts make a degree.

The surface of this platform is apparently now about fifty feet above the level of the water, at the lower extremity of the rapids. Its surface is in many parts quite bare, and deeply channelled in a direction parallel to the river. It is covered with heaps of pebbles and boulders of great size, some of which are hollowed and scooped into the most fanciful shapes. This sort of *pierres figurées* is also found, but much smaller, below the falls.

One of the largest of the blocks now left dry, marked in the plan and section, (Plate XVIII, letter F,) standing nearly in the middle of the elevated platform, is worn through perpendicularly with a cylindrical hole. Cases of a similar nature occur in the horizontal beds of chalk on the shore of the coast of Antrim; in the bed of the Taff in Glamorganshire; and near the rapids of precipitous rivers in all countries; indicating the long continued action of a tide or rapid current rolling on its own axis a loose hard stone, which has got embayed so as to impede progressive, and allow only of a rotatory motion.*

The rock is a slaty form of the common red granite of Finland, but contains more mica which lies in black plates between the laminæ. This sort of granite is very easily disintegrated, and is found every where falling into gravel from the mere action of the weather. The laminæ of the slate are nearly vertical, but what inclination they have is from west to east.

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* Cavities thus formed have been designated by the appellation of Rock Basins, a term which is also applied to the irregular pits and cavities often found on the surface of crags and blocks of granite and coarse sandstone, and which are referable to the action of the atmosphere and rain upon the irregularly decomposing surface of the rock. Good examples of granite thus acted on may be seen on most of the granite hills of Cornwall, particularly at Cairn Brae, near Camborne, and in the neighbourhood of the Peak in Derbyshire; similar appearances occur on the summits of blocks of mill-stone grit.

The general breadth of the Voxa is about a quarter of a verst; for the greater part of its course it may be considered rather as a chain of lakes than a river. Immediately above its entry into the narrow gorge of Imatra, its bed is obstructed by an island and a multitude of rocks which just appear above water: similar collections of sunk rocks occur in two or three places near Sistola and also immediately below the rapids. The height of the hills which bound the valley on either side may be from two hundred and fifty to three hundred feet in some places.

The river rushes with inconceivable fury through this narrow channel, which is perfectly free from any insulated rocks during its whole space; and this being considerable, it is difficult to estimate the perpendicular fall. The noise, on approaching it from the southward, where its violence is at the utmost immediately before quitting the gorge, is tremendous; the birches which hang over it are stripped of their leaves by the spray and almost constant draughts of wind which rush down with the stream. The inhabitants say, the level of the water and that of the lake Saima lowers daily.

The formation of these rapids may be owing to the following causes.

The friable texture of the rock, which is generally observed throughout the country; its peculiar arrangement in this particular district in laminæ easily separable, from the component parts of the granite being disposed in plates; the circumstance of these laminæ being nearly perpendicular on the spot in question, consequently receiving the pressure of a great body of water in the direction in which they are most easily divisible. That the water has followed this direction is evident from the very remarkable overhanging cliff on the east, pieces of which are falling every season, and from the retiring one on the west, which corresponds to it; which cannot be better understood than by imagining the whole channel an immense fissure or gap, parallel to the laminæ of the rock.

The uniform width of the valley, the general level of the rocky table above described, its furrowed surface strewed with pebbles and boulders perforated and shaped with greater minuteness and indicating more waste of time than appears in those which have been subjected only to the diluvian waters, and the case of the block which has been drilled perpendicularly with a cylindrical hole, shew the probability there is that the river once extended from hill to hill, forming a sheet of water equal in breadth to what it now presents above and below the gorge, and full of insulated rocks scattered throughout its whole bed.

From the softness and peculiar nature of the rock, (possibly also some small pre-existing fissure, along the line of the present channel, having once allowed the stream to hollow itself a bed in that direction sufficiently deep to contain all its waters) this table land has been gradually left dry, and at last appears at so considerable a height above the daily sinking level of the river; which may in process of time produce similar phenomena in the stony parts of the wider basins near Sitola, although the direction of the channel which the stream must find for itself will of course vary with circumstances.

It is needless to say, that the observation of the gradually falling level of the waters of the Voxa, and of the lake Saima, of which it is the only outlet, greatly favours every part of this theory. The increase of current, from the confinement of the stream to so narrow a channel, will account for the great depth to which it has sunk, considering also the nature of the rock.

The height to which the rock appears bare on the west bank agrees perfectly with the supposed former level, and the ordinary nature of the banks of this river.

N.B. The Voxa has no communication with the harbour of Viborg or gulph of Finland, although nine out of ten of all the maps that have been published of the country represent it as following that way.

The separation between the primitive rocks sand sandy strata of this district passes nearly along a line drawn south-west and north-east from the Berezowsky or Birch Islands, on the Gulph of Finland, to the west shore of the Lagoda, a little north of Kexholm, passing behind the chain of lakes formed by the Voxa.

On the shore of the Isle of Walaam, in the north part of lake Ladoga, a magnetic sand is found composed of octohedral grains of menachanite, with felspar and quartz in very unequal proportions, resembling the sand of the Platten Sea. It is washed up out of the lake by storms; at other times none is to be found on its shores, nor has it yet been found in any of the rocks of the continent of Finland.

Notice of the Bursting of the Lake Souvando.

In the spring of 1818, the lake of Souvando, (Pl. xvii) on the west of the Ladoga, which is separated from it only by the little isthmus of Taipala, underwent a change that will probably alter its future geographical character. Till that time it had poured its waters into the Voxa at Kevgnemy, and so passed on into the Ladoga at Kexholm. In the last spring (1818) the water broke down the isthmus and the lake ran backwards, and continues still to run into the Ladoga, having deserted its former outlet, the Voxa; the water having been lowered 5026 fathoms, much land is left dry, the lake being about 40 wersts long.

XVII.—*On the Geology of the Banks of the Ganges, from Calcutta to Cawnpore.*

By JOHN ADAM, M.D.

[Read Feb. 19, 1819.]

THERE is no rock on the banks of the Hoogly, nor do we meet with any after entering on the main stream of the Ganges, until we approach the province of Bahar. The soil, in general, seems to consist of a mixture of argillaceous earth and sand, in such proportions as to make a soft attenuated compound, excellently adapted for the purposes of vegetation, and conducing, in a great degree, to that fertility for which the plains of Bengal are so celebrated. The only peculiarity in these ingredients of the soil is the great abundance of mica, which, mingled in minute grains, often gives a brilliant shining appearance to an extensive plain of sand, and is found to prevail, more or less, on the banks in the whole course of the river. Strata of sand, of various colours, are frequently lying over each other, which seem to have been formed in successive seasons; and above these, mixed soil or sand approaching to it, with a surface destitute of herbage, or bearing a coarse grass or reeds, in detached parcels.

After leaving the low lands of Bengal, the Rajemahal chain of hills presents itself, and diversifies the prospect and character of the country. Here, for the first time, we discover rock; and from this point commences the series of specimens which is the subject of the present communication. I regret that I could not command leisure to examine any of these hills, excepting such as are situated close to the river, on the borders of which several of the lateral ranges terminate, and form beautiful projecting points of land. One of these terminates at the village of Sicligully, by a low mount composed of a crumbling rock of a dark colour.

At the village of Pointy, or Pierpointy, the rock was of several varieties, composing large boulders about two feet in diameter, and heaped together on the top of a low hillock, the greater part of which they appeared to form. At the waters edge, I observed the same sort of rock disposed vertically, and over that a softer sandy stone, which seemed to be undergoing decomposition.

At Vidasrong, or Dewal-point, which was the next spot in the course of the river that presented any objects for geological investigation, I found masses of rock lying on the strand, some rounded, and others of an irregular outline. They are of a compound nature, granite with hornblende, and conglomerates of quartz and mica with calcareous cement. The rock of the adjoining mount resembled that of Sicligully and Pointy. The base of the mount is composed of a breccia of quartz and limestone, and the upper two-thirds of sandstone. No regular strata are observed in these rocks, although something like a horizontal arrangement of the breccias appears at one or two points. The sandstone is placed in projecting masses over the others, but does not exhibit any stratification.

Opposite to the village of Colgong, three small rocky islands rise out of the stream, about one fourth of its breadth from the right bank. The appearance of these is highly picturesque, presenting huge blocks of bare rock, surmounted by trees and shrubs, that give a variety and liveliness to the scene. The rocks exhibit no stratification, but are thrown together in immense masses, standing on end, or lying with their long axes in a horizontal position, and piled one above the other to the height of 100 or 150 feet in the most elevated isles, the summit being terminated by a block more conical and pointed than the rest. The structure of these rocks is different at different parts of the islets; but their general constitution appears essentially the same, varying only in the proportion of ingredients, the arrangement which these relatively observe, and the more or less sound and undecomposed condition of each. Granite is most generally met with; it is found in huge blocks lying prostrate at the water's edge, or rising with bold pointed terminations to the summit of the island. Mica slate, like the former, is found in masses, but not of the same size, nor reaching so high; it may be considered as that rock in the first stage of disintegration. Gneiss and mica slate are found at the lower part of the island; and in a similar situation granite appears to graduate into mica slate. Between many of the blocks of granite reaching to about one third of the elevation, but chiefly at the water's edge, I found a conglomerate consisting of quartz and felspar, with a calcareous cement.

In the lowermost isle there appears some difference in the arrangement of the ingredients of the rocks. This islet rises like the other two, boldly from the stream, and ranks second in point of height. Granite is equally abundant in this islet as in the other two, and occupies a similar situation. Granite, gneiss, and mica slate, occur in detached masses at the bottom of the islet.

Similar to the elevations at Sicligully, Pointy, and Vidasrong, is that of Juangira, between Bhaugulpore and Monghyr. There is a pile of rocks consisting of granite with hornblende, about twenty feet high at the water's edge, and the same rock occasionally projects from under the surface at different parts of the declivity, and appears to constitute the whole of the mount. It does not possess any regular arrangement into strata. Opposite to this point there is a small islet in the stream, the general aspect of which resembles those of Colgong. The same kind of rock prevails here as on shore, with the exception of one mass.

Sitacund, celebrated on account of a hot spring, is no less remarkable for the existence of bare rocks in its neighbourhood, which present altogether a new spectacle. Near the adjacent village, there are several ridges of no great extent, running in a direction across the river's course, the extremity of some of them being bounded by it, and the rock projecting into the water at one or two points. Beyond these there are hills of a much greater height, that appear to be wholly composed of the same materials; the bare rock shewing itself from the base to the summit. The distance inland prevented me from visiting these, and I was obliged to confine my examination to the two which I perceived nearest the landing place. One on the south side of the spring is wholly composed of a white granular rock, the strata of which are almost vertical, and run in the common course of the ridge from west to east; they have a slight inclination towards the north, and the direction from west to east is intersected at some places by divisions so regular and uniform, as to appear the natural arrangement. The varieties of rock to be met with, are, 1. Quartz rock, the most common; 2. the same, but of a black colour, and appearing to possess a higher degree of lustre; 3. white granular quartz and sandstone were found in small masses between the strata of quartz. The hill on the north side of the hot spring at Sitacund presents a ridge of greater length than the former, running down to the river. From the regularity of the divisions here, it appears difficult to determine whether the direction of the strata is from north to south or from west to east. The position in regard to the horizon, like the former, is nearly vertical; the slight inclination being however to the south instead of the north. Quartz rock is the most prevalent here. The hot spring alluded to is distant 500 or 600 yards from the river, and rises out of the level ground about midway between the ridges. At the time I visited it in November last, it was running in a full stream, but before and during the early part of the rainy season, I was told it is always dried up, and when low indicates merely the common temperature. I found the sensation of heat intolerable when the hand was immersed in it, and Fahrenheit's thermometer stood at 140 degrees at all parts, as well near the surface as within a few inches of the bottom. Excepting the increased temperature, this water possesses no sensible properties different from rain or common spring water; it is clear and tasteless, and although I had not the means of applying chemical tests, I have since learned from a friend who made the experiment, that these indicated no peculiar impregnation. Gas was constantly disengaged from the surface in large bubbles, which I attempted in vain to collect. Many virtues are attributed to the waters of this spring in the cure of diseases; and the Brahmans, who wait on it, derive considerable emolument from the crowds which resort thither for relief. I could discover nothing peculiar in the local situation of this fountain, or in the nature of the soil out of which it flows. The adjoining district, which was under cultivation, seemed to be a strong clayey loam; and then bore flourishing crops. On leaving Monghyr, the country becomes again flat, and we meet with no rock on the banks of the river for upwards of 200 miles, until we reach Chunar; at this place several low ranges are seen running in a similar direction to those below Monghyr. The hill, from which the specimens were procured, appears to be the termination of one of these; it rises, with a gradual diminution of its circumference, to the height of several hundred feet; and on the summit is placed the fort of Chunar, which derives its principal strength from the natural steepness of the elevation. The rock on the north-east side is disposed in horizontal strata, so regular and uniform, that at a short distance it appears the work of art, and might be taken, from the colour of the stone, for a buttress built of bricks. On the opposite, or south side, however, the rock projects at various points, with a slight degree of elevation above the horizon; but though not so beautifully regular as on the north-east, the strata in general observe the same direction. Specimens of both yellow and reddish micaceous sandstone were taken from the north-east side; these appear to differ only in the colour and cohesion of their particles. The country around Chunar abounds with stone of a similar description, and at Mirzapore it forms a principal article of traffic.

From Mirzapore to Cawnpore the banks of the Ganges exhibit no rock; and rolled stone is found no where in its whole course. The clay, however, sometimes assumes all the hardness and solidity of stone, and is scattered over the borders of the river and the adjoining fields in various shapes, indicating, by the irregularity of surface, and the general stalactitic appearances, its having been thus altered by deposition from water. The specimens collected consisted of limestone and breccia, from near Bhaugereperest, and siliceous and calcareous sandstone, with mica much water worn, from the wells at Ghazypore. I observed a beautiful arrangement of these figured stones in the channel of a small stream which had been recently dried up; they were about a foot high, and connected at the summit, so as to form a platform supported by a series of descending pillars, some of which were complete, and in contact with the surface of the ground, and others, having been of later formation, reached only to within a few inches, yet they were very hard, and sonorous in some degree when struck one against the other.

The waters of the Saone and the Jumna, the two principal streams which enter the Ganges on the north side, are quite free from any earthy impregnation, and their beautiful clear colour forms a striking contrast with the muddiness of the latter at the part of junction.

XVIII.—*On the Geognostical Situation of the Reygate Stone, and of the Fuller's Earth at Nutfield.*

By THOMAS WEBSTER, Esq.

SECRETARY OF THE GEOLOGICAL SOCIETY.

[Read May 1, 1819.]

EVERY observation that tends to determine more accurately the geognostical place of any bed must be of some value, but more particularly if it be used for an economical purpose.

On this account I gladly availed myself of a late opportunity of examining *in situ* the well known Reygate stone, which is so extensively employed in London and its neighbourhood.

I believe the first author who described the situation of this bed was Mr. Farey, who, in the list of the English strata which he gives in his Survey of Derbyshire, states, that the lower chalk, or that without flints, gradually becomes harder and more sandy towards the bottom; and that in this bed the Reygate firestone is situated, an opinion which I believe is still entertained by some.

In a memoir which I had the honour to present to this Society, and which is published in the 2d volume of its Transactions, as also in the table which I formed of the upper beds of England from the observations made in the Isle of Wight and other places, I ventured to consider the Reygate stone as identical with the green sandstone; but as in this I was guided by a series of strong analogies rather than by actual knowledge, and as this arrangement has been quoted and followed by several persons who have since published elementary books on geology, and descriptions of the English strata, it appeared incumbent on me to bring to a test the accuracy of my statement.

Two circumstances were chiefly attended to in the subsequent examination:

1st. The nature of the constituents of the bed in question, and of the subordinate beds which it contained.

2dly. The relative place of these beds, and also of those above and below them, with which they are connected.

The soft Reygate stone is essentially composed of fine grains of siliceous sand and of mica, cemented by earthy carbonate of lime, and it contains also a small quantity of dark green particles usually called green earth: this latter substance is not so abundant as is generally the case in the green sand formation, a glass being necessary to observe it, but it is never totally wanting.

The earthy state in which the carbonate of lime exists occasions the stone to have little durability when exposed to the weather: accordingly, although it has been much employed in ancient buildings, (particularly where carving was used,) it is a bad material, as may be seen from its state of decay. When fresh quarried it is extremely soft; and it is the practice to keep it in the dry for several months, by which it acquires some hardness; a neglect of this precaution has sometimes occasioned its speedy decomposition. Its use is now restricted to filling in walls, and to the construction of hearths and covings for fire places, a purpose for which it is extremely well adapted, being easily worked, and resisting better than any of our stones, the heat of the fire.

The town of Reygate stands upon the ferruginous sand, a bed inferior to that which forms the subject of this communication; and the celebrated excavation under the ancient castle of Reygate is dug in it. The quarries of Reygate stone were formerly considered of such consequence that they were kept in the possession of the crown, and a patent of Ed. III. exists, authorizing them to be worked for Windsor Castle. Henry the Seventh's chapel at Westminster was also built of the stone procured from them, as is also the church at Reygate. These ancient quarries were situated between the town of Reygate and the chalk hills to the north, and traces of them may still be seen in several places, as at Gatton park, Colley farm, and Buckland green, which latter place is the most westernly spot where the stone has been found. All these works, however, are wholly abandoned, as the stone is procured in a point more convenient for the London market, at the village of Merstham, three miles north-east of Reygate. From this place it is carried by a rail road to the Croydon canal. At Merstham it is close to the chalk, on which account the relative situations of each are more easily observed, as will appear from the accompanying section taken across the country from north to south.

A A. fig. 5, plate 38, represents an extensive pit at Merstham, worked in the indurated chalk marl, or grey chalk as it is called by some, which is situated immediately under the lower chalk, or that without flints. A series of these pits extends along the escarpment of the north downs, and shews the dip of the chalk to be to the north, generally about an inch in the foot. Turning to the south, a steep descent, B C, conducts to the opening of the stone quarries D, which consists of a drift, BE, in a lower hill, the beds of which dip also to the north, and extend under the chalk marl. This drift is carried about two hundred and fifty yards, and the stone is drawn up by a steam engine. In this quarry I found layers of *chert* of several inches in thickness, which are so characteristic of the green sandstone, and also alternating thick beds of hard stone, or *rag*, similar to what occurs in other places where the green sand is found. This rag differs from the soft fire-stone, chiefly in having the calcareous matter in a crystallized state, the other ingredients, the siliceous sand, the mica, and the green earth, being the same. One branch of the drift is carried into the beds of the hard stone. To the south of this hill, the ferruginous sand bed is seen cropping out, and evidently below the level of the quarries.

On putting together all these circumstances, viz. the nature of the Reygate firestone, and its subordinate beds of chert and hard rag, its situation below the chalk marl and above the ferruginous sand; and comparing them with the nature and situation of the green sandstone in other places, for instance, at the Undercliff in the Isle of Wight; the identity of these formations appears to me as evident as any with which I am acquainted: and whatever may be the anomalies in the history of the English strata, yet here, at least, no difficulty presents itself, but only such slight differences as every new locality exhibits. The bassetting or outcrop of the stratum we have been considering, is distinctly traced running west and east, keeping parallel to the chalk of the north downs.

Stretching in the same direction, and about two miles to the south, is the hill or ridge on which Nutfield stands, the road to it from Merstham, F G, being cut in a soft but highly ferruginous sandstone, through which it continues to the top of the hill. On the summit are the fuller's earth pits, H, open to the day. There are two varieties of this substance; an upper bed of six feet, I, of a yellowish colour, and a lower one, K, of ten feet of a slate grey: the first is most esteemed, though they are usually mixed. In these beds are sometimes found crystallized masses of sulphate of barytes, of a beautiful yellow colour; the interstices between the crystals being frequently filled up with translucid white quartz. The crystals of sulphate of barytes are rhomboidal prisms, but specimens with terminations are rare. Masses have been met with weighing a hundred weight. These beds of fuller's earth are covered by a about fourteen feet of a rock, L, having the general characters of the green sandstone, containing layers of flattened nodules of hard rag or limestone, as at Western lines, Isle of Wight. I consider this, therefore, as a capping of green sandstone forming the summit of the hill; and the fuller's earth consequently occupies a situation between it and the ferruginous sand, in fact, the situation of the blue marl of the Isle of Wight. There are four pits of fuller's earth at some distance from each other in Nutfield Ridge, west of the village of Nutfield; and this substance is found in Redstone-hill, but is not worked there. Further to the south, and at a lower level, the ferruginous sand extends into the Weald of Kent. Cockham-hill, south of Reygate, is ferruginous sand; and about two miles to the south, in Earl's common, the Petworth stone with shells is found.

XIX.—*On the Smelting of Tin Ores in Cornwall and Devonshire.*

By JOHN TAYLOR, Esq.

TREASURER OF THE GEOLOGICAL SOCIETY.

[Read June 4, 1819.]

As I am not aware that the treatment of tin ores, or the mode of smelting them, has been recently described, and as the practice is confined to a certain district, it may be acceptable to the Society to have some account of the processes now used in Cornwall and Devon.

Tin ores are found in two kinds of deposits; first in veins accompanied by various other minerals, and secondly in alluvial matter in detached fragments.

It is usual in Cornwall not to apply the word ore to the oxide of tin, but to distinguish it, when in that state, by the term *Black Tin*, in contradistinction to white tin, which appellation is applied to it when smelted and in the metallic state.

The two kinds of tin ore above mentioned are therefore generally known by the names of *Mine Tin* and *Stream Tin*; and as they are for the most part smelted separately, and by different means, and as the metal produced from them is different as to its purity, it may be essential to point out the causes from which this diversity seems to arise.

Mine Tin is, as I have mentioned, the produce of veins, and is raised with a mixture of all the substances which unusually accompany it. There are, not unfrequently, copper ores, pyrites, wolfram, micaceous iron, &c. and the separation of these, as also of the earthy matrix, is the object of various processes of dressing, which are conducted with the greatest care, and require a considerable portion of labour.

Whether, in a country where fuel for smelting is on the whole very cheap, it might not be economical to diminish the labour of dressing, and by leaving more to be done in the furnace, reduce the expense of the former operations, is a question that I have never submitted to a direct experiment, though I conceive it to be one worthy of trial. The various earths may be quickly separated by fusion, as in the case of copper ores, which are now always smelted with a large mixture of the different kinds of spar in which they are found, all of which is easily run off by the fire, and the scoria or slag separated from the metallic part.

The fusibility of tin offers a mode by which it may be separated from an alloy of most other metals with which it is found to exist in veins, as lead and zinc ores are seldom mixed with it. This property is now made use of to a certain extent in refining tin, and might probably be taken advantage of still further, so as to avoid some of the charges incurred in dressing the ore.

The metal produced from Mine Tin is always of inferior quality, owing to the mixture of other metals, and which it is probable could not by any mode be entirely got rid of; it is known in commerce by the name of Common or Block Tin, and the quantity forms a large proportion of the whole that is brought to market.

Stream Tin is found in the lowest stratum of alluvial matter, in the bottoms of deep vallies, or places where a considerable deposit of mud, sand, and gravel, has been made by the action of water; it is often discovered occupying a thin bed incumbent on the rock, and covered by an *overburden*, as the streamers call it, which is sometimes from twenty to seventy feet thick. The tin is in rounded fragments, sometimes as large as walnuts, but more generally in the state of small gravel and even of fine sand; it is imbedded in loose matter, composed of the detritus of the rocks from which it may be supposed to have been separated.

The principal peculiarity of Stream Tin is the absence of any other metallic mixtures, except nodules of hematitic iron ore, which sometimes accompany it. This circumstance fits it for producing a very pure metal. This is not the place to speculate on the causes which have so completely freed these ores from substances with which they were in all probability originally combined, or to enquire whether it is to be attributed to mechanical action, or whether it has been effected by decomposition; but it may be remarked, that besides the hematite already mentioned, only the indestructible metals, and the oxide of tin, are now discovered existing in deposits of this nature.

The operations of dressing Stream Tin are simpler than those for Mine Tin. It is smelted also in a different manner, and produces a superior metal known by the name of *Grain Tin*, which is principally used by the dyers, and for the finer purposes.

The processes for dressing Mine Tin are in many respects the same as are used for all other ores, but are subject to some variation, which are attributable to the following peculiarities.

1st. Being for the most part found intimately dispersed throughout the matrix, the whole is necessarily pounded down to a very fine state to admit of the perfect separation of the ores.

2d. That being unalterable by moderate degrees of heat, it admits of calcination, by which the specific gravity of the sulphurets or arseniats with which it is mixed, may be lessened, and a mode obtained of rendering them more separable.

3d. That the weight of Tin Ore being greater than most others, it is less liable to waste in the processes of washing, and therefore may be dressed so as to be nearly clean from all substances not actually adhering to it.

From the first of these peculiarities it follows, that all tin mines must be furnished with stamping-mills of sufficient power to bruise down the ores raised, which is generally done so as to produce a minute division of the whole, and on this account, formerly, the quantity and fall of water that could be applied to this purpose usually limited the quantity of ore that could be returned from a mine, or the whole was frequently carried to some spot favorable to the erection of water-wheels to be applied to this purpose. Within a few years steam power has been applied to stamping-mills, and has tended to increase the supply of tin ores. Engines for this purpose, of considerable power, are working with great effect at two of the largest tin mines in Cornwall, Wheal Vor and Great Huas; from which are now arising abundant returns of the metal, and where formerly it would have been impossible to have produced it.

The state of division, or the size, as the tin dressers call it, is regulated by a plate of iron pierced with small holes, through which the whole passes from the stamping-mill, being washed through by a rapid stream of water conducted upon it for the purpose. This is a point of great importance, and is regulated by the state of dissemination in which every ore is found.

It is not the intention of this memoir to detail the processes of dressing which are common to most ores, and therefore it may be sufficient to remark that, after being stamped, the tin ores are washed according to the usual mode, so as to separate the earthy mixture and as much of that of a metallic nature as is possible. All these operations are conducted with more than common care and accuracy; for as tin ore holds such a large proportion of valuable metal, it is of course treated with every precaution to guard against waste.

Some metallic substances will be found, however, which, from their specific gravity approaching nearly to that of tin ore, or rather exceeding it, cannot be removed by any process of washing; these are mostly decomposible by a red heat, which the oxide of tin will bear without alteration. Therefore, after as much has been done as possible to render the ores clean on the dressing-floors, they are taken to the *burning-house*, which is furnished with small reverberatory furnaces, on the floor of which the ores are spread and submitted to the action of a moderate and regular fire: they are frequently turned over by an iron rake to expose fresh surfaces, and a considerable volatilization of sulphur and arsenic takes place; the former seems principally to be consumed, and the latter is condensed by long horizontal flues constructed for this purpose. After the ores come from the burning-house, the process of dressing is completed by further washing, which is rendered easy by the alteration which has been produced in the relative weight of the substances.

Copper ore is not unfrequently present in these cases, and, as it is in part converted into sulphat of copper, the water which is first used is preserved, and a portion of copper obtained from it by means of iron.

The great specific gravity of the tin ore, as I have before remarked, renders it possible with care to subject it to many operations in dressing without much waste; and they are therefore applied until the whole is generally so clean, as to yield a produce of metal equal to from 50 to 75 per cent. In this state they are sold by the miner to the smelter, who determines their value by assaying a sample, carefully taken from the whole quantity.

The furnaces for smelting Mine Tin are all of the common reverberating kind, and are of sufficient size to hold twelve to sixteen hundred weight of ore.

The charge is prepared by mixing it with a proportion of stone-coal, or Welch culm, to which is added a moderate quantity of slaked lime; these are turned over together and moistened with water, which prevents the too rapid action of the heated furnace, and which would otherwise volatilize some of the metal before fusion commenced.

The heat employed is a very strong one, and such as to bring the whole into perfect fusion; it is continued seven or eight hours, when the charge is ready to draw. For this purpose, the furnace is furnished with a tap-hole leading from the lowest part of the bottom, which during the process is stopped with clay or mortar, and under which is placed an iron kettle to receive the metal. The furnace has also a door at the end opposite the fire-place, through which the slag or scoria may be raked out from the surface, while the tin is flowing out, by unstopping the tap-hole.

They are thus divided, and the tin is laded into moulds, so as to form plates of a moderate size, and put by for a further refining. The slag, which rapidly hardens into a mass, is removed to a dressing-floor, where being broken up and stamped, it is washed, and a quantity of tin taken from it, which is called *Prillion*, and which is afterwards smelted again.

No operation in smelting is more easy than that practised for tin ores, nor is there any one in which the reasons for the mode of treatment are so obvious. There are but two things to accomplish in this first process; to obtain perfect fusion of the earths so as to suffer the metal to separate easily from them, and to decompose the oxide of which the ore uniformly consists.

The addition of lime contributes to effect the former, and that of carbonaceous matter or coal completes the reduction of the ore. The separation of the metal from the earths then takes place in the usual way during fusion, by the difference in their specific gravities, the one precipitating to the bottom of the furnace, from whence it is drawn off by the tap-hole, and the other floating on the surface is removed in the manner I have described.

The plates of tin, which are the produce of this smelting, are somewhat impure, and are more or less so according to the quality of the ore which has been used; they are reserved until a sufficient quantity of them are obtained to proceed with the refining, which is performed either in the same furnace, after ore-smelting is finished, or in a similar one, which may be reserved for the purpose.

All the processes for refining metals in the fire must be performed by taking advantage of some property in which the metal operated on may differ from those with which it is alloyed, and which it is intended to separate from it. These differences may consist in the facility or difficulty of oxidation, in their tendency to volatilize, in the temperature required for fusion, or in their relative specific gravities.

Upon an attention to the two latter circumstances are founded the operation for refining tin. The substances which are most to be suspected in the produce of the first melting, and which it is desirable to separate, will probably be, iron, copper, arsenic, tungsten from the wolfram, which the miners call mock-lead, and a portion of undecomposed oxides, sulphurets or arseniats, and of some earthy matter or slag.

The furnace for refining is raised but to a very moderate degree of heat, and the plates of tin being placed in it, are suffered to melt very gradually, and the metal flows from the furnace at once into the kettle, which is now kept hot by a small fire placed beneath it. The more infusible substances will now be left in the furnace, and a further purification of the tin is obtained by agitating it in the kettle for some time, by an operation which they call *tossing:* this is performed by a man with a ladle, who continues for some time to take up some of the melted metal, and pour it back into the kettle from such a height as to stir up the whole mass and put every part into motion.

When this is discontinued, the surface is carefully skimmed, and the impurities thrown up are removed; these consist of such matters as are lighter than the tin, but which are suspended in it, and being disengaged by the motion, find their way to the top. In general, the metal is at once laded into the moulds, after the tossing and skimming is completed, but the produce of impure and irony ores may yet require that the tin be divided as much as possible from the mixture which may yet remain. This may be effected in a great degree by keeping the mass in the kettle in a melted state, by which the parts which are heavier than the tin will sink to the bottom, and by leaving a proper portion behind, the tin will be materially improved.

The last operation is that of pouring the metal into moulds, which are usually formed of granite, and which are of such a size as to make it into pieces of somewhat more than three hundred weight each. These are called blocks, and are sent according to the provisions of the Stannary Laws, to be coined by the Duchy Officers, and it then comes to market under the name of *Block Tin*, or a certain part which has been treated with more than common care, is called *Refined Tin*.

The making of *Grain Tin* from the ores from stream works is conducted in a manner altogether different, and remains to be described.

I have pointed out the purity of these ores, as regards their freedom from a mixture of other metals, and I do not think it important here to describe the mode of separating them by washing from the sand and gravel in which they are found, because the processes are very similar to those in use for dressing other ores. The stream tin is generally made very clean, and is carried in this state to be sold for smelting, to establishments which are called Blowing-Houses, being thus distinguished from Smelting-Houses in which Mine Tin is reduced, and the term is also descriptive of the process employed.

The reduction of the ores for Grain Tin is performed by blast furnaces, and the only fuel used is charcoal. This mode of smelting is exceedingly simple, and is probably the most ancient one, as would appear from relics sometimes met with of furnaces of rude construction, and in some of which the wind alone seems to have been depended on for urging the fire.

The furnaces now in use are similar to those met with for smelting iron in foundries where the blast is used, and are formed by a cylinder of iron standing upon one end and lined with clay or loam. The upper end is open for receiving the fuel and ore which are thrown alternately, and a hole at some distance from the bottom at the back of the cylinder is provided to admit the blast, and another, lower down and opposite to it, suffers the metal to flow out regularly as it is reduced.

A strong blast is kept up by bellows, or, in more improved works, by pistons working in cylinders, and the air is conducted by a proper pipe so as to blow into the orifice in the furnace.

The only purification it seems to require is to separate from it such substances as are mechanically suspended in it, and for this purpose it is laded into an iron pan or kettle where the fusion is kept up by a gentle fire underneath, and a complete agitation of the mass is effected by plunging into the melted metal pieces of charcoal, which have been soaked in water, and by means of an iron tool, keeping them at the bottom of the kettle. The water in the charcoal is rapidly converted into vapour, which rushing through the metal, gives it the appearance of rapid ebullition. After this is over, and the whole has rested some little time, the scum which is thrown up to the surface is taken off, and the tin, which is peculiarly brilliant in appearance, is removed by ladles into proper moulds to form the blocks in which it is generally sold.

Grain Tin is, however, sometimes put into a different form by breaking it: for this purpose the blocks are heated to such a degree as is known to render the metal brittle; they are then raised a considerable height from the ground, and being suffered to fall, the whole divides into fragments, which assume a very peculiar appearance.

The smelting by a strong blast is injurious to metals that are volatilizable by heat, as they have in this mode no protection from the slag, which in reverberating furnaces floats on their surface and protects them from oxidation and evaporation. The old practice of melting lead in what are called Ore Earths, is on this account giving way, and reverberating furnaces are coming into general use, by which the produce of metal from the ore is considerably increased. Tin, though volatile to a certain degree, is not affected by the process in any important manner, but as some flies off in white fumes, it is usual to construct a long horizontal flue, which is made to communicate with and pass through a kind of chamber, in which a considerable part of these fumes is condensed and collected.

XX.—*Description of the Rocks which occur along a portion of the South Coast of the Isle of Mull.*

By the Right Hon. EARL COMPTON,

PRESIDENT OF THE GEOLOGICAL SOCIETY.

[Read May 21, 1819.]

THE basaltic rocks of Carseg are, I believe, very little known, either to geologists, or to travellers in general. They are, however, well worthy of the attention of both, and it is chiefly with the hope of attracting the observation of some member of the society, more capable than myself of doing justice to the subject, that I am induced to draw up this brief account.

I visited this remarkable coast last January, at a time very inauspicious for the purpose, not only on account of the shortness of the day, but also of the inclemency of the weather. In addition to these untoward circumstances, the impossibility of proceeding at that time in a boat rendered it necessary to walk a considerable distance over very rough and difficult paths. I had no means for accurately measuring angles or heights, nor for ascertaining the bearings of the compass, and these circumstances must plead my excuse for any inaccuracy on these points.

The coast of Carseg lies on the south side of the Isle of Mull, one of the largest of the Hebrides. It is formed by high precipices, sometimes coming down nearly into the sea, and sometimes receding a little from it. About the middle of the most remarkable part of the coast, in one of these recesses, is situated the farm house of Carseg, which may be taken as a fixed point from which to proceed. About a quarter of a mile to the eastward of it, I passed a small quarry of free-stone; this may be about the same distance from the shore, and about fifty or sixty feet above the level of the sea. I speak from recollection, having made no memorandum on this particular point at the time.

About a mile further on, are three whin dykes, visible in the rock, and very near to each other, (Plate 19. fig. 1.) The first of these dykes is nearly perpendicular, about one hundred and twenty feet in height, and about five feet and a half in width near the ground; but I understand from a gentleman who has since visited it, that he has ascertained it to be about seventeen feet in width at the top. Part of this dyke has fallen, and has left a recess in the face of the rock, about fifteen feet in depth at the summit, and about seven below. The face of the rock, which is basaltic, is formed of small columns in different directions. The second dyke is about the same thickness and height, contorted, and dipping a good deal to the eastward of the perpendicular. The third dyke, which is but a few yards distant, is seen at the turn of the rock, and again at another turn immediately following. It is about the same thickness as the other two, and dips very much, perhaps about forty-five degrees to the north-east. It is lost after its second appearance, sinking into the ground in a small cavern.

Beyond this is a fine cascade, about one hundred and ten feet in height, called Urie na Claorich a Buie, with basaltic columns, nearly perpendicular. The rock after this rather rises in height, and again displays fine basaltic columns. Very near this, another whin dyke is visible, almost perpendicular, though a little contorted. Further still, are some remarkably fine basaltic columns;

indeed much sharper and finer, I think, than they are in general at Staffa.

On the shore appears a small whin dyke, a few inches thick, and running in a direction about north-west and south-east. A little farther, is a very curious insulated rock, standing on the sea shore, about one hundred yards from the main rocks of the coast. It is of a very singular form, and basaltic, with very distinct columns, some of which are nearly horizontal. It is a curious circumstance that no columns are visible in that part of the precipice directly opposite to this rock. The name of this rock is Uamh Doun, and it is about seventy-two feet in height, as I have been informed. I was unable to proceed further to the east, but I understand that the interest of the coast in that direction is far from being exhausted.

Between the house and Carseg, and the three whin dykes, there are, under high water mark, rocks on the shore of a very dark colour, and micaceous texture, containing cornua ammonis. As my path lay considerably higher, and as my time was fully occupied, I was unable to visit them. Except these micaceous rocks, and the small quarry of free-stone already mentioned, I am not aware of any rocks, not basaltic, between Carseg farm house and Uamh Doun. The basaltic rocks to the eastward of Carseg, being more compact than those to the westward, have fewer cavities and imbedded minerals.

Proceeding now to the west of Carseg, at about a quarter of a mile from the house, and on the sea shore, is seen a small whin dyke, about eight inches thick, rising but a few inches from the ground, and running in a direction about north-east and south-west. The range of rocks is much higher to the westward of the farm, than to the eastward, the former varying in general from perhaps about two hundred feet, to five hundred in height; the latter are perhaps not half so high. To the westward they are not entirely basaltic. Accompanying this account is a drawing of one part of the coast, Pl. 19, fig. 2, where are seen irregular strata of free-stone and green sand, surmounted by a very regular row of basaltic columns; at the foot of the rock is a talus covered with grass. I have named the strata as they appear to the eye, for I believe they are inaccessible. I should suppose that the summit of the columnar range may be about one hundred and fifty feet above the base of the rock. I believe these rocks are higher behind the columns, though I was too near to ascertain the fact. The name of this rock is Stona Buoch. On the shore appear limestone rocks containing anomiæ, belemnites, and other fossils.

At one spot, about a mile and a half from Carseg, there is a rock coming forward at about a right angle with the rest of the coast, shaped like a wall or dyke, and about twelve or fifteen feet in thickness. This rock is formed by two strata, dipping considerably to the north, the upper one being sandstone; but my memoranda do not state what is the lower stratum.

This rock is called Bidda vich Archesh. The meaning of this name I have not been able to learn, but mention it, as I have done other names, to assist others to find the rock. In spelling the word, I have followed the pronunciation as nearly as possible.

At a considerable distance further on, is another small rock of two strata, standing on the talus of the main coast. The lower one basalt, the upper one green-sand-breccia. The name of this rock is Clach na Neigan, meaning, as I am told, stone of nails, alluding probably to the angular pieces of flint imbedded in the green sand. On the top of the main rock, which is very high, stands one resembling a square castle, and called Bidda na Neain, or the Pinnacle of Birds. I conceive it to consist of basaltic columns, but its height, and perhaps also some mist in the atmosphere, prevented my being able to distinguish whether it was so.

At the distance of about a mile and a half beyond this point, and about four miles from the farm house of Carseg, are the two arched rocks, which are the principal curiosities of this extraordinary coast, (Plates 20 and 21.) The large arch is called in Gaelic, Uamh-uill, or the pierced cave, from its being open at both ends. It is about sixty feet high, and between fifty and sixty broad, running east and west, nearly straight, for about one hundred and fifty feet. It is nearly of the same breadth and height throughout, but rather declines to the east. The roof of this cave is irregularly semicircular. The rock which it pierces is basalt, resting on green sand. It comes forward from the main coast, and is, I should think, from one hundred and ten to one hundred and twenty feet in height. Over the arch is a stratum of basaltic columns, irregular in height, varying in that respect from about ten to forty feet; a small grassy hill of a few feet rises above the columns. The main rock of the coast to which the arched rock is attached, is of basalt, about four hundred feet high, and at about half that height are seen irregular strata of columns inclining in different directions.

The smaller arch is called Bidda vich Re Lochlin, or the promontory of the son of the King of Norway, because a Norwegian Prince is said to have been lost there. The rock which it pierces is small, narrow, and high, detached from the coast, and standing to the west of the other cave. It is from one hundred and ten to one hundred and twenty feet in height, and the arch is about seventy feet high, but much narrower than the other, and a very few feet in length, from the want of breadth of the rock which it traverses. The direction of this cave is nearly north and south. On the top of the rock is a row apparently of single basaltic columns, as if it were a columnar dyke. Two of these columns stand by themselves, one having probably fallen which connected them with the rest. The base of this rock, as well as of that in which is the great cave, is green sand, in coarse grains. The small arch is very irregular in its form, as will appear by the accompanying sketch. The sea washes through both these arches at high water. I should not omit to say that this account of the great arch is taken from its appearance on the western side, as the state of the tide made it inaccessible on the eastern, which as I have already mentioned, is lower than that on the west. I was unable to proceed more than a very little way beyond the arches. Fossil shells appear in the green sand, but they are not numerous.

I found in basalt, very near the arches, a red crystallised substance resembling felspar; also a yellow variety of the same mineral. In different parts of the coast, between the arches and Carseg, I found in the basalt, crystallised carbonate of lime, chalcedony, quartz, radiated zeolite, prismatic zeolite, acicular zeolite, and analcime; also a bluish mineral, with the nature of which I am unacquainted, but I think most resembling a pitchstone. I also succeeded in finding on the shore some green jasper, like that from Rum, but coarser, and a red crystallised opaque mineral, the forms of whose crystals were not ascertainable. I also met with a very pretty variety of amorphous quartz, of a kind of violet hue, intermediate between the colours of amethystine and rose quartz. A little way inland, and behind the farm house of Carseg, has been found analcime, with foliated zeolite. Perhaps it may not be uninteresting to add, that plumbago has been recently found near Pennycross, several miles from Carseg.

XXI. *Account of a Variety of Argillaceous Limestone, found in connexion with the Iron-stone of Staffordshire.*

By the Rev. JAMES YATES, M.A.

MEMBER OF THE GEOLOGICAL SOCIETY.

[Read January 21, 1820.]

THE variety of limestone here referred to is called by the miners *Curl.* The name evidently alludes to the convoluted form of its distinct concretions, each of which is either itself a complete and regular cone, or is wrapped round part of a cone, which serves as the basis of its structure. Each distinct concretion, on being parted from the conical surface to which it has been attached, presents on its concavity a series of wrinkles, regularly indented, and always parallel to the base of the cone. The *convex* surface is longitudinally striated. The circular bases of the cones project a little one beyond another, and thus give to the external surface of the mass the appearance of leaves folded over one another. Hence has arisen the conjecture, that the mineral in question is a petrified palm, or lotus. This opinion would have been immediately abandoned, if those who adopted it had descended into the bowels of the earth to see the substance in its natural situation, instead of merely inspecting the detached masses of it, which, in the neighbourhood of Cosely, are seen on every side, lying upon the ground, or used in building walls.

The fracture of this mineral is splintery; its colour greyish black.

The masses, which are exposed to the weather, soon acquire externally a yellow rusty aspect, from the combination of oxygen with the iron which they contain.

The curl is here found in connexion with one stratum only. This is a bed of iron-stone, called the Bottom Stone of the New Mines. Beneath the measures, which, during a long period of time have been worked for coal and iron-stone in the great mining district of Staffordshire, lies a second series of strata called the *New Mines*, because they have only been worked for about sixteen years. The chief part of the iron-stone in this series of strata occurs in two beds of a few inches in thickness, which, unless so far as they are interrupted by faults, are supposed to extend continuously through the whole of this basin. The upper bed, *a*, (Fig. 6, Plate 38,) is called the *top-stone*, and the lower, *b*, the *bottom-stone*. They are separated by a bed, about two feet in thickness, of the greyish-blue slate-clay, which the miners call *clunch*. This substance also forms beds both above and below the beds of iron-stone, and contains disseminated balls and flattened nodules of iron-stone.

The bottom-stone is generally about four inches in thickness. But, at irregular intervals, it swells into great protuberances, *c*, *c*, which increase its thickness, in some cases, to half a yard. These protuberances are occupied by *curl*, the iron-stone remaining of the same thickness as in the parts where there is no curl. When the whole stratum has been blown up by means of gunpowder, the curl, as there is no natural parting, is separated from the iron-stone by strong blows of the hammer. The masses of curl thus attached to the iron-stone, and which appear to be of contemporaneous formation, extend in very various and irregular forms through spaces from five yards in length to twenty yards. At the edge of the protuberance, the cones are small, scarce half an inch in length;

but, as it swells to a greater thickness, the size of the cones increases proportionally, until they are a foot in length from the apex to the base.

In the mine which I inspected, (*the Coppice-mine*) the protuberances are attached to the under side of the stratum of iron-stone, never to the upper; and the base of the cone is placed downwards, its apex being directed towards the iron-stone. This is seen to be the case, where the stratum has suffered no disturbance, and, according to the information I received from the miners, the curl is not found in this district attached to the upper surface of the iron-stone in any instance. I have however observed masses of curl, into which the iron-stone penetrated so as to surround and inclose a portion of the curl. In these specimens, the apices of the cones were always presented towards the iron-stone, so that the bases of cones proceeding from opposite surfaces of iron-stone, were presented to one another, and, but for a small interstice partly filled with clay, were brought into apposition.

The stratum contains small veins of calcareous spar, passing vertically, and without interruption, through both the iron-stone and the curl beneath it. These veins intersect one another as in the reticulations of septaria.

The Staffordshire curl has been recently employed in considerable quantities for making *Roman cement*, for which purpose it is burnt and ground to a fine powder.

Curl, (or, as it is there called, *curl-stone*,) is found in the Shropshire coal-field at Prior's Lee, Sned's Hill, and Ketley. At the Ketley iron-works it was once employed as a flux, instead of common limestone; but its application to this use was abandoned. Its occurrence in that district is mentioned by Mr. Arthur Aikin, in the Geological Transactions, vol. I. p. 197.

Mr. Sowerby has given two representations of this mineral in his British Mineralogy (vol. II. plates 148, 149); and we are there informed that it occurs near Sunderland, at Bartonfel in Cumberland, at Boulby in Yorkshire, and in Derbyshire. The variety found in Derbyshire is described and figured in Martin's Petrificata Derbiensia (Wigan, 1809) plate 27, fig. 4. It is found immediately above and attached to a stratum of iron-stone which extends from Tupton Moor to Staveley.

In the collection of the Geological Society, are specimens from the clay-slate from the vale of the Dyfy, near Machynlleth, in Merionethshire. They differ very considerably from the Staffordshire and Shropshire specimens in fracture, in colour, and in the size of the distinct concretions.

From the information of Dr. G. Forchhammer, I am also enabled to state, that this substance (to which Werner, not long before his death, gave the name of *dutenmergel*, or *funnel marl*,) is found at G'ororp's Mill in Shoenen, and in the island of Bornholm, near the town of Rónne. It occurs at those places in a coal-formation, and is attached to a stratum of sandstone.

XXII. *On a new Pentacrinus from Lyme Regis, a new Encrinus, and a Briarean Pentacrinus.*

BY GEORGE CUMBERLAND, ESQ.

HONORARY MEMBER OF THE GEOLOGICAL SOCIETY.

[Read March 5th, 1819.]

SINCE my last communication, a singular variety of Pentacrinus having been discovered near Lyme, of which I had the good fortune to procure a specimen, it is with pleasure I transmit drawings to the Society taken from my own specimen, as well as from some fine ones belonging to Mr. De la Beche.

Fig. 1, Plate 22, shews the branching arms, which have considerable resemblance to the species found most commonly at the same place, and called by Mr. Parkinson, the Briarean. It differs from it however in being thicker in proportion throughout.

Fig. 2 is the part from whence the arms spring, and the two out of the five processes to which they were attached, which are visible, are remarkably well preserved. This lies on the under side of the lower part of the stone, figured No. 1, and is in all probability the identical summit of the column to which the arms of that figure were attached. The stem or vertrebal column is peculiar, from being in its lower part so nearly circular, that at first it passed for an encrinus, (see fig. 1 & 3, Plate 22) but towards the head it exhibits, as one of the drawings will shew, a decided pentagonal form, (see fig. 4, Plate 22) each division being bounded by a circular exterior, and between each division, as in the *Briarean*, there issue feelers, which this specimen shews must have been short, and of a form little diminishing, each occupying the groove from whence they issue when folded up.

The order of arrangement of the Trochita is a repetition of four: the first of considerable thickness, projecting most, and thickest in the grooves; beneath this reposes a thin one about one-third the thickness of the first mentioned trochite, which is separated from another of the same size and form by a middle joint of about half the thickness of the first, and which recedes a little in the column. Of the number of the joints of the feelers I am not able to judge, not as yet having seen any that amounted to more than ten. It was found in the same limestone as the Briarean for which Lyme is so celebrated, and most resembles a Pentacrinus which is in the British Museum, brought from Boll in Germany, but, I believe, has never been seen before in our limestones.

The annexed drawing (Plate 23, fig. 1) is from a new and very peculiar species of Encrinus, whose arms are doubled only once, and the joints of which very much resemble the Isis coral: parts of these arm joints I have found in the Severn lias, but this is in another species of limestone more resembling our transition rock, and although I am not yet informed of its locality, I strongly suspect it to be from the Severn sea.

The spherical body connected with it seems extraneous.

Fig. 2, 3, 4, & 5, Plate 23, represent correct drawings, in three points of view, of a separated pelvis belonging to the Briarean Pentacrinus, in which the insertion of the stem into the five bracketlike members is distinctly exhibited; and it will be observed, that a small process is inserted between each of the five larger ones.

The interior will be found, I trust, interesting.

Fig. 5 represents the natural size.

These objects I desire may be added to my other papers on the same subject, and the drawings annexed to those I formerly sent.

In my next letter, I propose to communicate a pretty perfect drawing of the Shropshire Turban-encrinus, never as yet entirely made out; also the decided radicles of that and the Tortoise-encrinus of the limestone, with all its parts; accompanied by drawings of at least two species of the Tortoise-encrinus of the chalk strata, differing from that in the limestone in its decidedly having no connecting stem, as well as in the number of the plates. These will be from more perfect specimens than have been hitherto published. They came from the upper chalk beds of Sussex, and are characteristic of them.

XXIII. *Description of Strata in the Brook Pulcovca, near the Village of Great Pulcovca, in the neighbourhood of St. Petersburg.*

By the Hon. Wm. THOMAS HORNER FOX STRANGWAYS,

VICE-PRESIDENT OF THE GEOLOGICAL SOCIETY.

[Read April 16, 1819.]

A PART of the course of the brook Pulcovca (or Poolkovka) affords some very remarkable sections, which throw great light on the nature of the district near St. Petersburg. About twelve miles south of that city, between the two roads from Petersburg to Tzarskoe Celo, which separate at Podgory, at the foot of the hill of Pulcova; a small stream, originating in some inconsiderable gullies, which drain the bogs on the west of the upper road, finds its way through a deep ravine to the village of Bolshoy Pulcova, where, issuing through a gorge in the escarpment on which the village is built, and along which is continued the lower or old road to Tzarskoe Celo, it enters the great bogs which extend towards Petersburg, and changing its name of Pulcovca for that of Chorny Rechca, or Black Stream, it flows by Coopchina, or Cupchina, through a small valley in the diluvian marl, to the Neva at Alexandrofsky.

On following the stream downwards, from the little bridge over which the upper road crosses it, nothing shews itself for a considerable distance but the blue clay, which forms the lowest stratum in the valley of the Ligovca; but the very regular sweeps which the river makes from *G* to *D* (Plate 24), and the repetition of cliffs almost exactly alike, at *F*, *E*, &c. exhibiting only blue clay and diluvium, although much higher than those, which, lower down, afford such complete sections of the limestone, are apt to perplex any one who approaches it from this side. At first sight, it might be expected that it would accompany the course of the stream down into the plain, as on the Cuzminka (or Coozminca); but, on the contrary, the long cliff at *D* presents a considerable section of the limestone lying conformably above the blue clay, and dipping, as is apparent from the strata being exposed on both sides of the river, towards the plain, instead of towards the hills which constitute the great body of the formation. The intervention of the black or green clay is scarcely to be traced at *w*, but a greyish or ash-coloured clay, drier, and more sandy than common, is found on the right bank, at *v*. On passing the point *t*, the strata suddenly turn upwards, and continue for some distance, producing the same dip.

This might be supposed merely a double section, which, in the case of strata highly inclined, often presents a deceitful appearance, and seems to show a change of dip which does not really take place; but, in this case, the point is too gently rounded for the circumstance to admit of doubt; and to make it still more evident, two insulated groups of rock rise from the middle of the river, at *s*, and *u*, within a short distance of one another, dipping rapidly towards the same point.

The river now flows in nearly a straight line to *M*. The right bank, which is high, is so covered with alluvial rubbish, that no rock is exhibited; but traces of the dark green clay are seen along the water's edge at *r*, opposite to which, at *q* and *p*, appear two remarkable sections of the same clay, but so separated from each other and from the nearest limestone rocks, by alluvial rubbish, that their connexions are only to be guessed at.

At *q*, the beds of dark green clay experience two sudden contortions, which give them somewhat the appearance of a camel's back; at *p*, they are seen perfectly perpendicular, and contain thin seams of whitish sand, which often accompanies this clay. The beds have a little twist at the top. All the rubbish here is of the debris of this clay, and shews the tendency to break into little bits like dice, which distinguishes this and the blue clay, as well as the clayey beds of the limestone in many places.

The beds of limestone, *o*, which succeed after a short interval on the left bank, are nearly perpendicular, with a considerable contortion at the top; but their line of inclination becomes gradually more regular, dipping towards the point where they were nearly perpendicular. To them succeeds the green clay, rising from under the limestone at *n*, but it is presently, as it were, doubled down upon itself, and forced to re-enter the earth in a direction nearly vertical, (Pl. 25, fig. 1). It is singular, that the beds which compose it retain their original parallelism to the incumbent limestone beds, much more than half the distance across from one side of this bow to the other, whilst the inflected beds, if not originally formed of their present thickness, have been squeezed into plates thinner by two-third parts than the beds which rise parallel to the limestone. These thin strata of clay are only bent, no where broken. Opposite to this contortion, the same clay appears at the waters edge, at *m*, under the limestone, which rises to some height on the face of the cliff *B*, but the stratification is not sufficiently distinct to shew whether it suffers the same violence as at *n*. Both here, and at *r*, the dark clay appears at a much lower level than on the opposite left bank, at *q*, *p*, and *n*.

The limestone again succeeds, at *M* and *Q*, above the dark clay, and dipping gently to the north-east. The cliff being much broken down between *B* and *M*, unfortunately prevents the discovery of the manner in which the limestone strata bend over the clay. This is the more to be regretted, as at *n*, where their junction is visible, it presents appearances well worthy of attention, and the cliff being also too low there to admit of our tracing the continuance of any of the limestone beds over those of the dark clay, their conformity appears almost doubtful.

Hitherto, (and indeed every where below this spot,) the three strata, however bent and thrown out of their apparently natural position, have preserved a stratification conformable to each other, wherever they have been found in contact, and it is probable they have found means to preserve it even in the difficult situations between *t* and *o*, though concealed from our observation. But here, at *n* (Pl. 25, fig. 1), the limestone in beds but slightly inclined, appears to abut abruptly against the beds of clay which are vertical, and even to join with it and pass into it as usual, gradually becoming a part of the same mass. It must be confessed, that at the place where the beds become green, the cubical fracture which characterises the limestone, renders it doubtful whether the strata are perpendicular with a horizontal cleavage, or horizontal with a perpendicular one; at the distance of a foot on each side, their contrary stratification is perfectly evident. It may turn out that this cross cleavage is only the effect of a sudden turning up of the limestone, similar to that of the dark green clay close to it. If the bank had not unfortunately been broken down, the limestone beds might have been traced over this arch of black clay: that being no longer possible, the difficulty seems to admit of no solution, unless some analogous nonconformities of these strata be hereafter discovered;

(see fig. 10, Pl. 25). At *Q*, the limestone soon becomes very nearly horizontal, and forms a sort of natural pavement on the left bank of the river, where the contrast of the different colours which alternate in this and in many other places is very remarkable. This is attempted to be represented in the drawing, fig. 2, Pl. 25, as well as the cubical fragments, which, when the beds are thus strongly coloured, and in some instances spotted with green and yellow, or red, resemble the remains of a tesselated pavement. The right bank, however, now claims our attention.

Under the projecting point *H*, the strata, as on the opposite bank, vary but little from the horizontal line; where they do, it appears to be occasioned by the faults or dykes, *x* and *y*, which cut them through as far as they are visible. The disturbance they have caused is but slight; the dyke *x* has not displaced the strata on either side, as they may be traced at the same level by their colours, especially three of them, yellow, red, and green, which are brighter than those above and below. The beds rise gently on both sides towards this dyke. The dyke *y*, however, has altered their position, as is proved by the three coloured strata, which are at least a foot lower on the right side of it than on the left, but they do not turn up towards it. These dykes are each about two feet wide, and are filled with diluvian gravel, of the same nature as that which covers the plain and cliff above; part of the gravel in the dyke being softer than the rock, has been washed out by the water: if continued in a straight line, they must cross each other somewhere near *H*, but it is more probable that in reality they form but one dyke or fissure, not perfectly in a straight line. For although something like a continuance of the dyke *y* is seen among the rubbish at *z* on the opposite bank, where the water from some wet land, under the heights *J*, finds its way between some bushes to the river, yet nothing of the kind seems to occur opposite x, which should have been the case, were they to be continued in a straight line; and no trace of them is to be seen on the other side of the small peninsula formed by the river between M and Z. This is the only instance in which the strata appear broken through; in all their other accidents, they are bent, but never dislocated. It seems as if a rent, which first meets the river at z, having crossed it to y, by a small curve, cuts off the point of the rock H, and re-appears at x. The circumstance of its being filled with diluvium and boulders proves, if not precisely the time of its disruption, at least that its filling up was not anterior to, and probably contemporaneous with the deposition of the diluvium of the plain above; the evenness of the soil above, and the perfect conformity of the line of cliff, its face, and height, all seem incompatible with the idea of its being a mere landslip of recent occurrence (of which a good example occurs lower down the valley); an earthquake seems the only remaining post-diluvian cause which could produce such an accident, though it may be thought that the undisturbed appearance of the upper bed of diluvium and superficial soil is as incompatible with the one as the other. However, from the causes by which recent landslips are produced, it seems hardly possible, that a mass of hard rock like this should be so cleanly cut through, and that it should sink perpendicularly in the same spot in which the correspondence of the strata with those adjoining points it out to have been.*

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* It will be observed that the dip of the two bodies of rock on the outside of the dykes, x and y, (plate 24, fig. 3) is in the same direction, though at different degrees of inclination. Supposing, then, that in their original position the strata eg, (the coloured beds) were continued so as to join without interruption those parts now on the outside of the two dykes, they would not present a greater variety of dip than is now exhibited immediately* on

* This is only seen in the general view, (fig. 1, plate 25,) where it immediately overlies the black clay with pyritical nodules at k. The limestone in this valley exhibits fewer traces of petrifactions than any where else.

The limestone now rises rapidly on both sides of the river, (see fig. 1, pl. 25) and shows beds corresponding in colour under *N* and *H*; the dark green clay again issues from beneath it, at *k* and *l*: at the former place its beds are much bent, and are of considerable hardness; large fragments of it are seen in the river amongst the boulders. Here are found in great numbers the nodules of fetid limestone, as on the Pulcovca, also crystallized sulphuret of iron in flattish masses. Below this, the blue clay appears for a short space, at *i* and *j*; to which succeeds the green clay dipping again in a contrary direction at *g* and *h*, and though so lately in great strength (considering the ordinary weakness of this bed) at *k*, is now only traced by a strong line of dark green, accompanying a flesh-coloured or reddish yellow clay, as it sinks on both sides of the river under the limestone at *g* and *h*. This is the only spot where the junctions of the three strata have been discovered in the same cliff, the blue clay but seldom appearing under the green. The limestone now is seen forming the high cliff at *A*, and containing one thin clayey bed of white and red, very like the colours shewn by the inferior blue clay on the Cuzminka and Solticovca. It is also seen on the right bank, shewing the back of its different beds, dipping considerably to the north-east. To this succeeds alluvial rubbish for some distance, till at *L* the blue clay again appears, and is continued without interruption, (except from alluvial accumulations) on the banks and in the bed of the river, 'till it enters the plain below Pulcova. The limestone thus, at first sight, appears to have dipped under the blue clay, or (supposing any mistake could exist as to the dip of such

turning the corner of the promontory, *H*. Therefore there is nothing improbable in supposing that this was their original position. Then let that part of the central mass which is next the dyke *y*, sink from want of support, and the part which joins the dyke *x* will naturally incline upwards towards it.

strata as those at *A.*) to have disappeared without the presence of the dark green clay. However, on taking a bird's eye view from the heights, there appears ample room between the spot where the alluvium first obstructs our sight of the limestone, at *e* and *f*, and the point *L*, where it terminates, and exposes the blue clay, to allow of a sudden turning up of the limestone, and subjacent dark clay within the heart of the cliff, which presents on the outside nothing but alluvial debris; were the cliff higher, it might perhaps have been seen. To prove that this is not entirely conjecture, it may be stated that on the side of the opposite hill, at *d*, the superficial soil shews some signs of the dark clay, and though this alone might not be sufficient, yet it must be allowed to have some weight, when it is repeated a little further on (and at a greater elevation, which implies strata rising to the E.) and of less doubtful appearance at *b*. But to confirm this, there luckily lies immediately below *b*, in the bed of the river, a very large mass of the dark clay, in its most characteristic form, which has evidently been detached from the hollow, in which are seen the traces of it at *b*: and to put out of all doubt the fact of the strata having been turned up, and that they are now gradually disappearing (as they ought) to the east *above* the blue clay, there appear at a still higher level, *c*, near the top of the hill, *O*, a clayey variety of the lower beds of the limestone, exhibiting all its characteristic colours, and which probably does not extend much further east. It may exist under the hill *P*, but the accumulation of gravel is too great to allow of any thing being seen on that side.

In taking a comprehensive view of this interesting portion of country, we perceive that it must be considered as an insulated portion of the great Doodorof limestone; differing indeed from most outliers, in not forming a high cap or insulated hummock, but rather a mass which appears sunk or half buried in the blue clay, which may be traced without difficulty round three sides of it, viz. at *D*, and *O*, (plate 25, fig. 3) and towards Tzarskoe Celo; for it is not one of the least remarkable facts, and one that contributes much to the apparent confusion of this tract on a first examination, that of the three parallel streams and valleys which intersect this eastern ridge between the hill of Pulcova and Tzarskoe Celo (plate 25, fig. 2); the Pulcovca contains the three strata in great strength; the Cuzminca (the middle one) exhibits nothing but the blue clay; and the channel which conducts the waters from the gardens of Alexandrofsky towards the plain, near the village of Cuzmina, is cut in beds of limestone the most regularly horizontal in which it ever appears, (pl. 24, fig. 1. and pl. 25. fig. 1.) On the other side, the limestone may perhaps extend as far as the hill of Pulcova, the top of which, however, is a large deposit of diluvian gravel; but there is no reason to imagine it goes any farther; and the hill of Penty, the only one on this ridge which approaches that of Pulcova in height, shews no signs of it (pl. 27, fig. 1).

The landslip, at *e*, is a mere recent accident, occasioned by springs which issue in abundance from the sides of these valleys, and which, when the bogs on the table land are overcharged by the melting of the winter snows, are quite sufficient to produce such effects, and augment the streams to such a degree as to keep constantly undermining large cliffs, which in summer overhang inconsiderable brooks, or chains of stagnant pools; to this must be added the expansion produced by the alternate thaw and frost, which, on the face of cliffs and rocks where the snow does not lie, penetrates to a great depth. Even in summer, after sudden rains, these rivulets, flowing in deep ravines, and among and over vast boulders of granite, acquire the character of mountain torrents ,(Pl. 26, fig. 1).

This mass of dark clay, which has slipt from the boggy hollow about *b*, consists of perfectly parallel beds, gently waved, and traversed by two thin brown veins, which meet at the bottom, but do not displace them. It has a very singular appearance in the middle of the stream, the current of which it has nearly blocked up, and surrounded by blue clay, on which it stands, alluvial rubbish, and huge granite boulders, with a patch of yellow limestone on the hill above, not any one of which it seems to have any connexion with. Being of a soft substance, and exposed to the most violent part of the current, which it has here dammed up, it probably will not last many years, and has either been much larger, or a long time may not have elapsed since it was brought into its present situation.

XXIV.—*Geological Sketch of the Environs of Petersburg*;

By the Hon. Wm. Thos. HORNER FOX STRANGWAYS,

VICE PRESIDENT OF THE GEOLOGICAL SOCIETY.

[Read April 16, 1819.]

THE environs of Petersburg offer, at first sight, but few inducements to geological or mineralogical research; a great extent of flat country, apparently covered every where by alluvial formations, and boulders of the primitive rocks, is all that strikes the eye of the traveller, who is seldom tempted to explore the wildernesses that yet surround this capital, from their want of any thing that may be called picturesque beauty. There are, indeed, some few spots which may be quoted as exceptions; but they are mostly at some distance from the town, and are but little known even to the natives: and as the nature of the country gives no room to suspect their existence, it is not wonderful that they remain unvisited by strangers.

From this cause, perhaps, it arises, that there has hitherto prevailed an equal ignorance of the geology of the district to which the following observations relate. I have been told by some, that the whole country eastward from Narva consisted of a series of primitive rocks, which were said to shew themselves in the falls of the Narova above that town. Others have told me, that it was what is called a basin of the formations above the chalk; a question, which, until chalk has been proved to exist somewhat nearer to

Petersburg, than Podolia or Scania, it might be premature to decide. Others, again, believe it to be a country of coal measures, and are perhaps the most sincere in their opinions, having voluntarily put themselves to a great expense in boring for it in different parts of the country: these researches have hitherto been attended with results satisfactory to none but those who never believed in its existence in this quarter. Some appearances would connect it with the salt formation; others with the mountain lime. It has also been associated with the transition rocks, as they are called, more particularly grauwacke. Few, indeed, are the strata to which the name of the latter formation, the Proteus of geology, has not been applied.

The tract of country which it has been more particularly in my power to examine, may be comprised within a circle of about forty versts* radius from the fortress of Petersburg, taken as a center, (Plate 28). I may have occasion to mention some interesting points beyond these limits, connected, as it will appear, with the district under consideration, but which connexion I have not had the opportunity of proving, i. e. of tracing it step by step; but I hope by so doing, to give indications which will be sufficient for those who may hereafter visit the north of Russia with the same views.

The Delta of the Neva, extending nearly nine versts from north to south, is entirely comprehended within the gates of Petersburg; the Taracanovca,† or beetle, branch, which is the most southerly, flowing close by the new gate or triumphal arch on the Peterhof road, and the Wyborg gate being placed beyond the little Nevka, the farthest branch on the north. An alluvial plain extends for a short distance beyond the latter gate; it is probably part of the same deposit with the Delta, properly so called, but is at present joined to the first bank of the terra firma on this side, without the intervention of any branch of the river now remaining.

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* The verst, as now established, is equal to about three quarters of a mile English; formerly it was much longer, and still varies on different roads.

† So called from its abounding in taracans or beetles.

This Delta is not entirely built upon. The northern islands, in particular, are still low enough to be occasionally flooded, and their banks are in some places always marshy. The higher spots alone are covered with villas and gardens; the lower parts remain wooded. The southern islands, upon which the town stands, are considerably higher and drier; to this circumstance is owing its comparative freedom from the inundations, fogs, and countless swarms of gnats, to which the northern islands are exposed. The eastern extremities of the islands are the highest, as being the oldest; the western still low and marshy, being of a later date; while there exists, continually encreasing between them and Cronstadt, a set of submarine islands, which form at present a dangerous bar, and will at no distant period make a considerable addition to the Delta.

A tract of low marshy land, in some places nearly two versts in breadth, of similar origin to that just described, borders the two shores of the gulph to a distance of about forty versts on the southern, and twenty-five on the northern coast. It does not appear to be every where gaining on the sea; it is in some places stopped by the approach, in a contrary direction, of the sea-sand, which not only arrests its progress, but being blown over and mixing with the loose and wet ground of the marsh, forms a soil firm enough for the growth of trees and for agriculture: examples of this posterior accumulation of sand may be seen on the north shore near the village of Lakhta, east of the great marsh on the

Cesterbeck* road; and on the south shore at Peterhof, where a part of the gardens of the palace, and oaks, ash, and alder, of great size, are planted on the alluvial flat. The oak, if not the ash, are said to have been planted by Peter the Great; the alders, which both here and at Oranienbaum, as well as the pines at Becova, all planted on this alluvial plain, exhibit the marks of great age, may be still older, as they are natives of the country. It is remarkable, that between each of the three localities above given on the southern shore, there exists a small portion of the coast where the marsh still gains on the sea. This may perhaps be occasioned by a difference in the depth of water, which is in general very shallow.

This alluvial land does not extend far above the delta. The banks of the Neva, (at least of that portion of it which is below the sudden turn which it takes at Pella), consist of an accumulation of diluvian gravel, which will be hereafter more particularly described. Where these banks separate, the alluvial flats begin; the southern bank of gravel, being continued under a small portion of the town, is divided by the deep stream called the Chorny Bechka, or black rivulet (a common and appropriate name in this country for all the brooks whose waters are derived from peat bogs,) on the right bank of which stand the monastery and gardens of St. Alexander Newsky. About four versts from Petersburg, on the Peterhof road, the same bank makes its appearance, and is continued without interruption, except from ravines and brooks, to about fifty versts in the same direction, where meeting the present shore of the gulf, it forms the headland of Crasna Gorka, or the red hills. It will be seen that a change in its materials takes place at about half the distance, with which the name of this headland seems to be connected; the present description, it must be remembered, is merely topographical. This bank is very well defined, and continuous throughout its whole extent, with the exception only of that part south of the town, where the rise is insensible. The western portion of it, now separated from the gulph by bogs and marshes, has evidently been its ancient shore, as the eastern is now that of the Neva. Its average height is from thirty to forty feet, gradually rising towards the west. The great road to Riga runs at its foot, and the slope is ornamented with villas and gardens, being no longer dangerous from the undermining of the waters, which still affects the banks of the river above Petersburg.

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* In the Russian maps, Cestroretsk, of which Cesterbeck is only a corrupt German translation. Cestra reca, or Cester Back, meaning only the river Cestra, on a lake at the mouth of which the village and iron works commonly called Cesterbeck are situated.

A similar bank skirts the northern shore till it meets the gulf near Cesterbeck. With the exception of the great marsh near Lakhta, which interrupts it, it is more continuous than that on the southern side of the town, leaving the river near Okhta, and being easily traced behind the Wyborg gate to the village of Colomyagy, meets the marsh opposite Lakhta.

This bank appears in like manner to have formed the northern shore of the gulf, at a period when the alluvial deposits had not yet risen to the surface of the waters, and when the apex of the delta was the real mouth of the Neva. Where the banks became wider apart, and the current consequently slacker, the first deposit of sand was formed: this, at first a bar, then shewed itself above the level of the river as an ait or island; many of these at last formed the delta as we now see it, and as it is now, by a repetition of the same process, extending itself towards Cronstadt. As the breadth of the channel becomes gradually wider towards the west, and the water deeper, this deposition takes place slower and slower as it advances; and the silt or sand of which it is composed, being also finer in proportion to the distance from the original mouth of the river at which the depositions commenced, contributes to render the progressive increase of this, as of other deltas, apparently less rapid in these days, than it must have been formerly.

It has been proved by actual examination, that of three successive depositions which form the present bar, and whose slow but constant increase is become already a material disadvantage to the port of Petersburg, the first consists of small pebbles and all the coarser particles, the greater specific gravity of which has caused them to fall on the slightest relaxation of the velocity of the current; the second of a finer sand, and the third of the finest silt or lighter particles of earth, which have not been deposited until the stream, meeting the waters of the gulf, has thrown them wherever the eddies or still waters have become incapable of carrying them any further. It is not improbable, that the materials which form the basis of the older islands may be pebbles of a still larger size; even the isle of Cronstadt itself, which is also alluvial, may be accumulated over some great heap of boulders.* The surfaces of all the islands, however, are covered with a fine sand, which has floated the highest, and which prevents the ascertaining of this point.

These alluvial depositions are certainly very considerable, for a river whose whole course amounts not to more than seventy-five versts; especially if it is considered that its waters flow directly from a vast lake in which all their previous impurities must have been left. In consequence, its waters are perhaps purer than those of any river of the same size. Its supply of water from this source is, of course, very steady, and the streams it receives are too inconsiderable to affect it by their occasional irregularities of level. The frequency of floods is said to have greatly abated during the last century. Its course is remarkably free from islands, except at the mouth, there occurring but two or three in a bog at Astrafki, above Pella.

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* When the waters of the gulf are low, numbers of vast boulders may be seen stretching in reefs and banks to a great distance from the shore. The shape of the isle of Cronstadt agrees exactly with the idea of the alluvial tails described by Sir James Hall in the Trans. R. S. Edinb. 1813.

The silt brought down by the Neva is far from being a fertile soil; derived originally from two or three of the poorest strata in Europe for agricultural purposes, and lastly from the diluvian gravel, which form the banks of the river, in which sand greatly predominates.

Behind these banks, the course of which has been traced above, extends a level country on each side of the Neva to a considerable distance. On the north, it forms the isthmus between the gulf and the lake Ladoga. Its features are easily described. A ridge of hills runs due north from the great bend of the Neva at Pella to beyond Coltoushy, where it terminates. After an interruption of two or three versts, we find the insulated ridge of Biabova stretching in the same direction, and after another considerable interval, that of Toxova, which extends beyond Vola and Lembala to the chain of lakes called collectively the Voxa. A little to the south of Toxova, it turns to the eastward, forming the Capsala hills,* and is continued behind the marshes of Cesterbeck, sending out a small branch to Diboun, and a larger one towards Pargola and the lakes of Souzdalskoe: this latter runs parallel to those of Coltoushy and Biabova; and like them, presents its steepest escarpment to the west. That of the Corpsala ridge is steepest towards the south; that of Toxova has a declivity nearly equal on each side. Thus there are three distinct plains between the lake and the gulf; gradually rising in level towards the eastward.[*] The country is thinly inhabited, being covered with forest, bogs, and marshes; the soil poor and sandy.

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* Spelt in the maps Caropselky called commonly Copsala or Copselky.

Behind the south bank there extends also a boggy plain, for the most part covered with coppice wood, from five to ten versts in breadth. From this rises a well defined but not lofty escarpment, which may be traced throughout the whole of this part of the district under consideration. Its general course is from west to east, till at Palcova, a village about thirteen versts south of Petersburg, the hill of that name, which forms a prominent feature in the escarpment, turns suddenly to the south-east, and the ridge is continued in that direction (with a few irregularities, to be described hereafter) to the village of Fedorovsky; thence across the great Moscow road, nearly eastward, to a little above Nicolsköe on the Tosna: further eastward, it skirts in like manner the southern bank of the Neva and of the lake Ladoga, always at a few versts distance. It is interrupted by the denudations of the Strelca and of the Ligovca, in its western half, and by those of the Slavenca, [†]Ishora, and Jossna, in its eastern. The only ill defined part is between the hills of Coirova and that of Cargasary, but it is of small extent; this may perhaps be connected with a remarkable change in its structure, which takes place in that part of it. A chain of low rising grounds may be traced west of Coirova in continuation of this line; but, as will be seen hereafter, has no claim to the name of an escarpment, considered either geologically or topographically. They pass along the wood and village of

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[*] Of these three plains, that of Lakhta is raised but little above the level of the gulf; that which is east of Riabova but little above the lake. The difference of level between the lake and the gulf is said to be eighty-three feet.

[†] The letters *sh* in Ishora, are to be pronounced hard, like *s* or *z*, in the words *vision*, *cohesion*, *brazier*.

Gorela or Gorelova, that of Niccory, Khamouzy, and some others, and may be discovered still further westward. The village Khamouzy is placed on the highest elevation along this line, west of Coirova. Some groups of low hills are also seen behind Peterhof and Oranienbaum, of which that of Bronna or Bronnaia is the most considerable.[*] All these low hills are ranged in front of the principal escarpment described above, which seems to fall back a few versts, whilst the communication between the hills of Coirova and Cargasary is wanting to complete the chain. The vacant space is filled up by a gradual but boggy rise, in which the stream of the Chorny Rechka has its source. Behind this escarpment, or rather on the table land of which it forms the edge, is seated a group of hills of about eight versts in length, which begins at the east bank of the lake of Doudorof, and stretches towards Tzarscoe Celo. This group comprises the two hills of Doudorof and Teply Sad, two conspicuous landmarks over all the country, and the highest points in all this district. These hills, as well as the table land beneath them, are in general of a very dry but poor soil; there are, however, large tracks of cultivated land, especially west of

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[*] I have reason to believe that the following list of heights in the neighbourhood of Petersburg is correct. It was given me by an engineer employed in making a geographical survey of the country.

	Barom.	Trig.	
	Ingrian side of the Gulph.		
Bronna (behind Oranienbaum)	31·5		sand
Soikina (beyond Caporié)	58·3		doubtful
Doudorof (church)	78·1	77·2	limestone
Visotsky (hill)	66·4	68·5	doubtful
	Carelian side of the Gulf.		
Merstojersoy	39·7	42·4	sand
Voronina (opposite Cronstadt)		47·9	sand

These measurements are taken in sashenes or Russian fathoms, each containing seven English feet. The heights are computed above the Gulf of Finland, in which there is no tide.

the Ligovca river. West of it, as well as to the south of the hills of Doudorof, there are extensive and almost impassable bogs; further eastward, the country is again more peopled and cultivated. What I have called table land is not absolutely flat: that part west of the Ligovca is varied with narrow and parallel ridges of gravel, in the hollows between which are some deep but small peat bogs; while behind Coirova, where the whole country appears a bog, a few insulated villages, as Ruzina and Venerezy, &c. are seated on some accumulations of gravel, which rise as islands in the waste. Both in the boggy and in the dry district, the scarcity of running water is remarkable: west of Crasnoe Celo is a very considerable district, absolutely without it, contained within the Ligovca, the Strelca and the Poudost rivers.* Nor are lakes frequent; although they abound in the country on the north of the Neva.

The general face of the country, as it will appear from the sketch and the sections, Fig. 1 and 2, Plate 29, consists of terraces of great regularity, but inconsiderable height, supporting different tracts of flat country, on which a few insulated hills are placed. This description is equally applicable to the country on the left as on the right bank of the Neva, although there is a considerable difference in the soil and its productions. Nothing can be more dismal than the general appearance of that district on the right bank of the Neva. Sands and bogs afford but a scanty vegetation in the few spots where the woods are sufficiently cleared to allow of some miserable attempts at agriculture; and in the remaining tracts, the forests are for the most part stunted by the continual cutting to which they are subjected for fire-wood. They consist exclusively of fir and birch, and occasionally aspen, the few oaks to be found at Toxova and Riabova being attributed, as all those trees are in this part of Russia, to the forethought of Peter the Great. Grass is rare, being commonly replaced by lichen rangiferinus; the sand, which here contains little or no mixture of clay or lime, produces nothing but rye and buckwheat in small quantities. Only the abrupt declivities of some of the principal hills, and the banks of a few lakes, present scenes, which though certainly picturesque, are of a melancholy character.

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* The limestone escarpment, more especially that part between the denudations of Ropsha and Crasnoe Celo, is called in the old Russian maps, the Shoundorovsky hills, from the farm Shoundorova, still remaining on it, and which was probably the oldest settlement. The western extremity is the highest, and commands a magnificent view both towards the gulf and towards Doudorof, especially near the great oak. In the village of Rusky Coporsky, the limestone crops out in the street, yet the inhabitants send for limestone to Visotsky or Crasnoe Celo!

Nearly the same picture may be drawn of that portion of the tract on the left bank of the Neva, situated to the north and to the east of the principal escarpment; with the exception of those parts artificially adorned by the neighbourhood of the Imperial palaces, which are all on this side of Petersburg, and by the villas and summer residences of its inhabitants. But south of this tract, especially within the limestone district, the character of the country changes; large tracts of cultivated land and many populous villages are found along all the principal escarpment, and many parts of the country behind it; oaks, though perhaps not natives of the soil, are more frequent, and attain their full growth; even wheat is sometimes cultivated; the wych elm (ulmus montana), and a greater variety of plants become common, many of which belong to the Flora of central Europe, while those of the sandy districts before described belong principally to that of the north. In the valleys which lie upon the limestone and sandstone rocks, may be found many beautiful and picturesque landscapes.

If we examine the structure of the terraces and plateaus of which the surface of this country is formed, we shall see that they are, in fact, not table lands, fig. 3, pl. 29, but large shallow basins, the interior of which, for want of sufficient drainage, is now filled with peat bogs, while the edges or lips of these basins, which are, of course, much drier than the interior, become better adapted for agriculture, and are in consequence, together with the banks of the rivers, where the same cause operates, the only tracts inhabited and cultivated. To these may be added a few insulated deposits of gravel in some of the great bogs. But in every part of this country, over whatever stratum or in whatever situation, the superficial or vegetable soil is scanty in depth and poor in quality. A dry situation in a country generally so wet, and a climate, if not rainy, yet extremely variable, seems to be the principal object in the choice of a spot for building. Soil is but little considered in a system of agriculture where the peasant leaves his unmanured field fallow every alternate year, and where the government unavailingly offers rewards to procure from the land a return of five for one.

ANTE-DILUVIAN FORMATIONS.

PRIMITIVE.

*Although no members of the primitive formation occur *in situ* within the limits of the tract which forms the subject of these observations, yet it may not be unnecessary to mention the situation and direction of that district of the primitive rocks which is nearest to it in geographical relation. This is the granitic country of Carelia, which approaches to within a hundred versts north of Petersburg, possibly still nearer, although it has not yet been detected *in situ* nearer than Souvenoya, two posts from Wyborg. These granitic rocks form the southern portion of the primitive chain of Finland, connected on the west with those of Sweden and Norway, and on the east with those of the government of Olonetz and Arkhangel, which are probably a connecting link between Scotland and the Oural moun-

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* In the year 1819, a Synoptic Table of the different formations near Petersburg, was published in French, in one sheet, in that city, by the author of this memoir, accompanied by a table of lithographic sketches and sections coloured; also an old duodecimo map of the Academy was issued anew, and coloured by the Mineralogical Society.

From this table it appears, that with the exception of modern alluvium, and diluvian sand and gravel, the limestone No. I. is the most recent formation of that neighbourhood. From the nature of its animal and mineral contents it appears most nearly allied to the transition limestone of the English series. Beds connected with these deposites extend from Esthonia to the southern extremity of Lake Onega.

No. I.

Shelly limestone breaking into cubic fragments, disposed in beds moderately thick, and conformable to those of the subjacent schist.

Characters.	*Mineral Contents.*	*Organic Remains.*
a. hard, saudy, yellow	1. calcareous spar well crystallized	1. helix
b. hard, crystalline, black	2. green carbonate of copper	2. pentacrinites (doubtful)
c. tender, argillaceous, whitish	3. sulphuret of copper	3. fungites, &c. (same as at Reval)
d. hard, dark red	4. iron pyrites	4. orthoceratites
e. spotted with yellow, red & green	5. grains of green earth disseminated	5. trilobites
f. argillaceous, greenish, passing into the subjacent schist, a.		6. encrinites (paradoxus)
		7. terebratulites
		8. hysterolites
		9. lemon-shaped bodies resembling heads of alcyonium

No. II.

Schist argillaceous or sandy, usually in very thin laminæ, and subject to great irregularities of level as well as of composition.

a. schistose greenish clay, resembling f. of the preceding	1. green earth, very pure	1. chamites
b. alternating with sandy beds	2. yellow pyrites cubic	
c. yellow grit stone, mammillated	3. bronze coloured pyrites octohedral	
d. yellow sand, spotted with green	4. Sulphuret of lead	
e. quarzose grit, coarse grained	5. native sulphur and earthy ditto	
f. ferruginous sand, black or red	6. radiated nodules of bituminous limestone	
g. black schist, brown or green argillaceous, passing into (a) of the next inferior series		

No. III.

Clay not distinctly stratified; has been penetrated to a considerable depth without discovering the subjacent rock.

a. blue greenish clay, resembling g of the preceding	1. pyrites in small quantity	No organic remains have yet been found in this bed.
b. spotted with red and yellow	2. small flakes of mica	
c. intersected by veins of yellow clay	3. veins of yellow clay	
d. having a tendency to oolitic structure	4. grains of iron ore	

tains. This tract is therefore at the northern extremity of what has been termed the Great Basin of the North of Europe. I shall begin the geological detail with the lowest stratum, and proceed with the rest in regular succession from below upwards, according to their order of superposition.

* The basis or substratum of all this country is a blue clay, beneath which no other bed has yet been exposed. The highest stratum, both with regard to geological and topographical position, is a limestone, which presents no appearance of having been covered by any other orginal formation. Between these two, occurs an intermediate bed, whose presence is constant, but whose characters are by no means equally so. It is, in fact, a transition bed partaking of the characters of that above it as well as of that below it; to which are added some peculiarities of its own, which sufficiently distinguish it from the other two. In the blue clay there is no apparent sign of stratification, nor of organic remains; in the limestone are abundant marks of both; the intermediate bed in some of its forms is evidently stratified, in others that appearance is totally wanting; its organic remains are scanty and rare. These three beds are strictly conformable, as may be seen by their stratification wherever that is visible. Although perfectly distinct in general character, they pass into each other at their points of contact. I consider them therefore as members of the same formation.

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* There is some reason for apprehending that the blue clay, which I mention first as lowest in situ, does actually rest upon the primitive rock without the interposition of any other stratum. I shall have occasion to speak again upon this subject in the comparison of the secondary beds of this district with those of Sweden.

SECONDARY.

Blue Clay. *

Its colour is a pale blue or bluish white, generally with a tinge of green. In a few places (as on the Couzminka and on the left bank of the stream which flows through the old gardens of Soltikoff's Coirova) it is slightly sandy and micaceous, and variegated with red streaks; in which circumstance it resembles some of the clayey beds interstratified with the limestone. When dry it cracks into sharp angular fragments, usually affecting a square or cubic form, which is the common fracture of all the beds of this formation. It sometimes but rarely contains small crystallizations of sulphuret of iron, and at Samsonovsky an efflorescence of sulphur.

In that division of the clay district situated between the Coirova hills and the shore, there occurs a remarkable appearance in the

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* The three strata of this district bear the following names among the people of the country:

The Limestone	Pleta	in Finnish—Paas
Sand	Pesok	....
Sandstone	Brusok..................	Siroki ....
Clay	Glin......................	....

The correct name for Limestone, as such, in Russia, is *Eezeskovoÿ Kamen*. That of this country is called *Pleta*, a name answering more nearly to our word *Flag*, than any other, without reference to its composition, but rather to its schistose structure. The following are their distinctive names for stones:

Flag............	Pleta
Flint............	Kremen
Boulder	Kamen

The latter word *Kamen*, which means simply *stone*, is applied to the primitive boulders *par excellence*, on account of their hardness. There is scarcely a peasant also but knows Granite by name, if not by sight.

clay, which merits particular attention. It is best seen in the sides and bottoms of the ravines which the streams Ivanovka, Coirovka, and Crasninka, have cut through that bank of diluvian gravel which skirts the Peterhof road from Petersburg to Strelna. The natural channel of the Ligovca has been so obscured in this part by artificial works, that the clay is not seen to advantage in it.

There is a low cliff on the right bank of the Coirovca, between the village of New Ligova and the Peterhof road:* Immediately below the soil are some thin layers of a whitish clay, which cover a layer of pebbles slightly cemented together, and just hard enough to project a little beyond the beds above and below it. Thus far all seems to be diluvian, and agrees in character with that which is found immediately beneath the soil in all the neighbourhood. But under this we find the clay of the country, of its usual blue colour, with the exception of the upper part in contact with the bed of pebbles, which is yellowish; as are also certain veins by which the blue clay is traversed in various directions, though but seldom horizontally. These veins are from three to six inches, or even more in width; their substance is a yellowish clay somewhat like that which intervenes between the blue clay and the diluvian. Although these veins are not hard, they are of a firmer consistency than the blue clay which they intersect; they are usually very easily divisible in the direction of a ferruginous line which runs down the middle of each, and which separates, or is cut through, in exact conformity with the yellow clay veins themselves. The relative hardness, or rather solidity, of the blue clay and its accompanying veins, is beautifully shewn in every instance where they occur in the bed of the stream, or in places often under water. In such situations, the blue clay is uniformly washed out to the depth of about five or six inches; the large veins preserving that height round the holes thus formed. As the holes are gradually excavated, the upper part of the walls which surround them, not being strong enough to resist the stream, are carried away. The whole presents a sort of honey-combed appearance on a large scale, which I have endeavoured to express in the sketch. This may also be very well seen in the bed of the Ivanofka, and of the Crasninka above Crasnoe Cabac, the whole bed of which stream appears as if hollowed out of one vast septarium.

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* See Sketch of the clay veins on the Coirovca.

The three rivers abovementioned are the only ones in which I have found this singularity of the blue clay; it is not observable in the banks of the Ligovca, nor in those of the Chorny Rechka, either above or below Coupchina. In the former, we find only blue clay without veins, and in the latter, no blue clay whatever: the whole depth of its banks being composed of yellowish diluvian gravel.

The only good exposure of the blue clay, on the right bank of the Neva, is in a pit, whence the clay is taken for brick-making, by the side of the small stream called Chernavca in the great map of the environs of Petersburg, just where it quits the picturesque churchyard of Okhta. It is somewhat singular, that though visible here at so high a level, it should not be laid open in the lower grounds; the sand which forms the bed of the Okhta river is rather argillaceous, especially just below Mourina; as is that found on piercing the bogs east of Riabova, and that which forms the bottom of the larger lake of that name: but these being members of the same formation, it must happen, as in analogous cases, that they pass into and blend with one another.

South of the Neva, it skirts the shore of Peterhof and Oranienbaum; is seen in the beds of most of the streams which discharge themselves into the gulf on this side, especially those between Becova and Peterhof; appears farther inland through some of the boggy soils; may be followed up the Ligovca to the lower lake of Doudorof; up the Coirovca and its tributaries above the villages, where it is in great strength; further eastward, it is to be found in the ditches along the Tzarscoe Celo road to the foot of Pulcova hill, on the Pulcovca above and below the remarkable outlier, and on all the streams cutting through that part of the escarpment. Again it is in great force on the lower part of the Ishora and Tosna rivers near Podolova and Nicolskoe. But further eastward, it seems the valley of the Neva and basin of the Ladoga, and with them the whole country, becomes too elevated to allow the denudations to lay bare this inferior bed.* The blue clay is said to be traced along the whole southern shore of the Gulf of Finland, at least as far as Reval. Above it lies an

Intermediate Bed,

which I confess myself to be unable to designate by any name derived either from its appearance or from its composition; as it not only varies considerably in both, but consists of a number of alternating strata of various colours and substances, some of which are not always present, and where they are, differ greatly in their relative thickness and position. In fact, they appear to have no fixed relative position *inter se*, although taken as a whole, the series which constitutes that which I have named the intermediate bed is very constant in its place between the blue clay below and the limestone above it. It is also strictly intermediate in composition between those two beds, the lower portion partaking of the nature of the clay, the upper of that of the limestone. A minute description will therefore be necessary, as it is only by the occasional presence of some one or other of its members, that it is to be traced throughout a very considerable tract of country; and as some of these members in some parts of the district increase greatly in thickness, to the exclusion of those which accompany them in others, it is possible that it may exist in other parts of the north of Europe, where it has not yet been noticed. It is fortunate, that in a part of Europe, so easy of access as the neighbourhood of Petersburg, we find some spots where all its varieties may be examined in the same natural section.

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* The blue clay has been pierced to the depth of sixty-three feet, at the paper mill at Peterhof, and to twice or three times that depth on the banks of the Neva, without finding any subjacent stratum.

I shall therefore give the series of beds which compose this stratum, as they occur on the left bank of the river Ishora, exposed to view in a precipitous cliff partly overgrown with brushwood, but sufficiently accessible to allow of a minute examination of the rock, the variations of its character being in this spot more striking than in any other I could select. The banks of the Tosna, where they may also be seen to great advantage, are less accessible, whilst the thickness of the beds is so considerably increased, as not to allow of the whole series being seen in one vertical section; a circumstance which adds greatly to the value of those on the Ishora, in a practical point of view, as there can exist no doubt with regard to their relative position. Each bed is likewise of sufficient thickness to present a decided character, and the presence of both limestone and blue clay, one at the top, and the other at the foot of the cliff, determines at once the place of any of the beds wherever it may be met with.

The spot which I wish to point out for examination is a cliff about sixty or seventy feet in height, if not more, on the left bank of the Ishora, a little above the village of Samsonovsky, or Oloseen Mekky, from which it is divided by a narrow ravine without water. At the river's edge appears the common blue clay before described, which forms the base of a wide meadow occasionally overflowed by the river. On reaching the foot of the cliff, it passes into a sandy mixture, gradually acquiring a greater degree of purity as it approaches the upper beds. The most remarkable character is that of a brilliant white quartzose sand, of the finest quality, in which are excavated small caves, supported by pillars left in the rock, for the purpose of procuring sand for writing, or for hour-glasses. It has just sufficient coherence not to fall in. Next above this white sand is a bed of the same substance, differing only in its colour, which is a bright and beautiful yellow. These two beds, which are sufficiently obvious, may also be seen on the banks of the Tosna, Slavenca, and Popovca; also at Mishkina, and in the neighbourhood of Pavloosk.

It is in this part of the series that there occurs a bed which I must mention here, though I have only found it *in situ* at the rocks above Nicolskoë on the Tosna. It is a yellowish white sand, differing but little from those sorts just described, excepting that it contains organic remains. These are only one large species of chamite, in very good preservation, usually of a brownish colour, and retaining the original polish of the shell. Where found in situ, it is of very loose texture, readily crumbles between the fingers, so that it is impossible to bring away a characteristic specimen; and on weathering, offers some indications of a mammillated or botryoidal structure, which, it will be seen hereafter, is a remarkable feature in another member of this formation. It was first found in rolled pieces, and in small quantity, near Tzarscoe Celo; I have since found it in large rounded blocks and pebbles of great hardness, and affording excellent specimens, among the diluvian gravel on the summit of the hills bounding the north side of the vale of the Ishora, especially in gravel pits near Repolova, and Anteleva.

The two beds immediately above this consist also of a sandstone containing chamites: they are, in fact, a continuation of the last, but differ in some respects from it. The lowest is usually of a reddish or even rosy colour, and contains vast quantities of chamites, or rather fragments of them, strewed throughout its mass, in the direction of the planes of stratification. The upper bed is of a dark green or blackish brown colour, equally filled with chamites, some of which have a tendency to iridescence or metallic lustre. This circumstance, together with the regular laminæ in which they are disposed, gives them a certain resemblance to mica slate or gneiss, for which the rolled fragments, in which state this rock was first noticed, were taken. Its extreme hardness, even when *in situ*, the obscurity of the organic structure of the shells it contains, and its being found in company with rolled gravel entirely composed of masses of primitive rocks, some of which consist of real gneiss nearly resembling it in outward appearance, may account for this error. It is present on the Ishora *in situ*, but may be seen best where I first discovered it, at its outcrop in a quarry at the north end of the village of Slavenca, west of the river of that name, and south of Pavloosk.

Above these chamite beds the sandstone assumes a ferruginous aspect; its colour yellow, red, black or brown. It is seen in this state in the outlying ridge behind Peterhof and Oranienbaum; also throughout the neighbourhood of Pavloosk; and in a loose state, forms the hills situated to the north of Petersburg and the Neva.

Connected with this bed, is a mammillated or botryoidal sandstone, which occurs *in situ* in this part of the country, from the Popovca to the Tosna. It forms large beds of various degrees of hardness, usually of a yellow colour, and more or less charged with iron. It may be found at Nicolskoë on the Tosna in every state intermediate between a simple botryoidal sandstone and a heavy mammillated iron stone. It is *in situ* on the Popovca a little above the village, and near the white sand.

The succeeding beds become more argillaceous, and are of a dark brown colour inclining to green. They contain as much iron as those immediately below them, usually in the form of irregular masses of pyrites radiated in the interior; sometimes in bunches of crystals, exhibiting both the cube and octohedron with their modifications, as well as the bronze red and brass yellow colours. The superior beds are thinner and more slaty; their colour ash grey or purple passing into green and black. They are bituminous, and contain layers of fetid calcareous spar, disposed in nodules of a dirty brownish white colour, and radiated from the centre. They sometimes appear like rugged balls, the apices of the crystals projecting at the circumference.

These pyritical and bituminous beds are always very thin and sometimes much contorted. Their upper portion contains a vast quantity of green earth of very fine quality, which might be used for painting. These beds of green earth differ in character, the lower being argillaceous, passing into green clays immediately below them; the upper, on the contrary, although in appearance the same, are hard, contain lime, and pass gradually into the lower and argillaceous beds of the Pleta limestone, through which green earth is also disseminated.

The topography of this *intermediate bed* must be described under two different heads: one of which will comprehend its outcroppings from under the limestone, which it skirts throughout; the other its various outliers on each side of the Neva, which are not capped by any other antediluvian formation. I shall take the latter first, as the former will lead more naturally to the consideration of the limestone immediately above it.

All the chains of hills comprehended within that part of the district I am describing, which are situated on the right of the Neva, and which have already been mentioned in detail in the beginning of this memoir, are composed of the loosest and most sandy form of the stratum in question, as well as the plain which supports the bogs between the ridges of Toxova, Riabova, Coultoushy, and the lake Ladoga. This will be better understood by the section, fig. 4, Plate 29. The sand on the banks of the Okhta, especially below Mourina, and that west of Pargola, I imagine to be diluvian, for reasons to be stated hereafter.

Its colour is in general yellow, and it much resembles the sands of Prussia and the north of Poland, as well in geological character as in the scenery it presents. Nothing can be more desolate than the little valley of Diboun, in which a stream of the brownest hue, formerly dammed up for the purpose of supplying with water an iron work now removed, forces its way with difficulty through a bog impassable to human footsteps (as are many others in this country) except after 10° Reaum. of frost. In summer, its moist and heavy exhalations, exposed for some months to the sun during eighteen hours a day, rarely disturbed by a breath of air, and confined between tall and gloomy forests of fir and birch springing from the arid sand which presents no trace of other vegetation on its surface, than grey moss and some species of ferns growing among granite boulders, nourish myriads of gnats or musquitoes, gadflies, and all the other disagreeable insects which swarm in this climate during the warm season.

Although this is the general style of country, yet there are some spots of a more pleasing character, which also present the best situations for examining the characters of this sand. Such is the dell in which the Okhta runs above Mourina, especially in the gorge in which it is confined in passing through the hills of Copsala: the hills and lakes of Pargola and Souzdalskoe; the environs of Toxova, and the western ascent of Riabova. In each of these places may be seen considerable cliffs of sand clothed with the most beautiful and fragrant flowers of the north in the greatest luxuriance, particularly Convallaria bifolia and maialis, Andromedæ calycalata and polyfolia, Ledum palustre, &c. Pyrolæ, Orchideæ, &c.

At the western foot of Riabova, and of Coultoushy, and on the banks of some of the beautiful lakes of Toxova, the sand assumes a deep red colour, and contains a considerable portion of iron. The streams which issue from these hills are strongly tinged with it, and transport particles of it to a great distance. This may be observed also in some other places.

Those outliers of this stratum which occur on the south shore of the Gulf, afford in general the same character as those on the north, just enumerated. But, in a few instances, the sand is considerably harder and more compact, and though it may in general be broken between the fingers, yet it sometimes passes into a real sandstone, of a fine grained sugary texture, white or yellowish. This exhibits some faint traces of stratification: but after frost, the laminæ are seen separating very distinctly in all the fragments exposed to its influence. It is sometimes found large grained, and may almost be termed a conglomerate of quartzose particles, each about as large as a grain of rice, strongly cemented by iron. The best localities for examination are, the valley at Peterhof, between the Emperor's English garden and the paper-mill bridge; and a small ravine and brook between Sopsana and Becova, also remarkable for the finest oaks near Petersburg, planted by Peter the Great; and in some other ravines along that coast. I have reason to believe this portion of the sand skirts the coast at least as far as Crasna Gorka headland; its exact termination on the east I must be content to leave undetermined.*

I must now proceed to that portion which may be called the principal mass of this stratum; and which underlies the limestone which it may be seen skirting along its whole escarpment. My farthest certain locality to the westward is Caporié, where it occurs in its state of purest green earth; thence it is traced westward by Ruditza, Gastilitzi, along the Shoundorovsky escarpment; in the ravines on the west side of the valley of the Ligovca, at the foot of the heights of Crasnoe Celo, in its most bituminous state; in the ravine of the Poulcovca in its most pyritical state, a character which it preserves along the Tzarscoe Celo escarpment as far as the brook Coshelevka: on the Popovca it begins to be sandy, which character increases rapidly as it advances to the eastward. The sandy beds increase in strength on the Slavenca, the Ishora and Tosna rivers, and wherever they may be seen in the escarpments between those points, where at last it totally banishes and occupies the place of the bituminous and clayey beds; and from the Popovca eastward it contains chamites and the beds of globular concretions.

In two places it occurs under a character still different from any that has been mentioned. On the upper part of the Ishora, in the neighbourhood of Anteleva and Lukozy, particularly at a cliff well known to those who fish in that river for trout and grayling, by the name of the red bank; it is much like the red ground of the central parts of England: for instance, on the banks of the Teme, in Worcestershire, to which this part of the Ishora bears some resemblance. Again it is seen with the same characters near the entrance of a considerable ravine or hollow in the Shoundorovsky escarpment, where the road from Gorela to Ropsha crosses a brook near the village of Niccozy; it is here slightly micaceous, and offers to the attention of the botanist the beautiful Epilobium hirsutum, the only spot where that plant is found near Petersburg. Towards Ropsha the outcrop is covered up (as are most of the eastern slopes of the vallies of denudation) by a thick bed of granitic gravel. The hill of Khamouzy, and the heights near it, are so covered with gravel and soil, that their composition cannot be exactly ascertained.

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* The sandstone is seen distinctly in the ravines between Peterhof and Strelna, but seems to have ceased before we arrive at the ravines and lakes of the latter place.

The Pleta Limestone

Covers the intermediate bed last described. It is a coarse limestone, the lower beds of which are very argillaceous, and contain a large portion of green earth: they are, in fact, only harder beds of the same substance as that which forms the upper part of the intermediate bed. The most common colour of this limestone is a yellowish grey, sometimes spotted or variegated with green, red, dull purple, and bright yellow, or even orange of different shades. The great mass of the limestone also contains much clay, which seems to have been favorable to the preservation of the organic remains contained in it; but the upper beds are considerably harder and more sandy, and contain much fewer traces of a former world. As there is no one section which gives so distinct a view of its beds and their peculiarities, as the cliffs of the Ishora do of those forming the intermediate bed, I must describe them in their order, referring to localities where they may be examined and identified.

Where the intermediate bed is argillaceous and charged with green earth, as may be seen in the ravines of Crasnoe Celo, the limestone in contact with it presents only modifications of the same characters. Thus in ascending the ravine of the Colomenca brook at Crasnoe Celo, from its mouth, the green sand beds become more solid as we ascend, and at last give way to a grey argillaceous limestone, sufficiently hard to form steps across the stream, which are very convenient to the geological examiner. This argillaceous limestone occupies nearly the whole mass of the heights of Crasnoe Celo: it abounds in organic remains, of which the following are those which are sufficiently distinct to have been named.

A species of orthoceratite of great size, being sometimes a yard in length, and six inches in width. Their outer shell, when preserved, which it rarely is, is channelled in the direction of the septa of the interior. A good specimen of this is in the cabinet of the Mineralogical Society at Petersburg. The casts of the siphunculus shew it to be channelled spirally; the inner shell is very thick, and large specimens are often procured; but the termination at either end is always wanting, having probably been too thin to resist violence. We are still therefore in doubt whether it was curved, or continued in a straight line to its extremity. They are seen in great quantities lying in the direction of the beds of limestone, but traversed by its perpendicular fissures.

Two species of trilobite; one, which has been called *trilobites caudatus*, is the most common; it has a head with two projections which have been taken for horns, but are probably prominent eyes like those of the lobster, with which this animal appears to have had some analogy. It has usually eight, or not more than nine plates, disposed in three rows, which in specimens well preserved appear to be jointed, part of each being double. It has also a large flap tail, which is often found preserved when the rest of the animal has perished: the shape of this tail is triangular, with a strong ridge or continuation of the back running down the middle; it is often protected by a thick shell, still remaining, under which the surface of the cast of the animal itself appears furrowed like the skin of the human thumb. The tail, when found alone, somewhat resembles a butterfly in shape.

The other species, which has been named *trilobites capitatus*, is much rarer; and has only been found as yet in the eastern part of the district. It differs from *trilobites caudatus* in having no tail, the plates being continued to the very extremity. In this it resembles some of those found in the grauwacke of South Wales and limestone of Dudley. But its most remarkable distinction is its head, which bears a remarkable face or figure. These figures were at first found without the body, as were the tails of the other species, and exercised in vain the ingenuity of naturalists, until they were at last luckily discovered attached to their respective animals.

Both these species appear to have possessed wonderful powers of flexibility, and are occasionally found rolled up with their tails in their mouths, and disposed in other singular attitudes. Their colour is usually brown.

I have found also some small terebratulites, and helicites, in the limestone of the Colomenca ravine. The latter are rather uncommon.

These argillaceous beds contain also balls of an unknown origin. They are round, oval or lemon shaped, with a knob at one or at each end. Their interior structure consists of a mass of radiated calcareous spar; and on the outside the pyramid of some of the crystals, which is very low, sometimes projects beyond the circumference. These have been supposed to be heads of alcyonites, analogous to those of the green sand of the Isle of Wight, and to be connected in origin with some obscure traces of stalks which the limestone sometimes presents on its weathered surfaces. But these stalks having never yet been found together with the balls, this is still only a conjecture. They may perhaps be only concretions of calcareous spar, similar to those contained in the black clay below, but in which the bitumen is wanting. They are found commonly in all parts of the limestone district.

Another variety of these argillaceous beds, which appears to be confined to the eastern borders of the limestone, is that which is thickly sown with brown grains of clayey iron ore, as some other beds are with green earth.* These grains have a slight resemblance to those in the red or upper beds of the inferior oolite of the south coast of England, and which also occur in France, but are not so black. I have not been lucky enough to find this variety *in situ*, but fresh fragments of it are not uncommon in the Popovca, Coshelevca, and other brooks.

Perhaps the most singular appearance which this limestone presents, is that so common on the Pulcovca and other places, where a yellow bed is, as it were, blotted with various colours, and where sometimes beds, coloured differently, alternate; as is the case on that stream with the red and yellow magnesian, and greenish varieties.† The contiguous surfaces of these beds are very rugged, although they separate without much difficulty: this circumstance renders this stone very unfit for paving, the use to which it is commonly applied in Petersburg. This form does not appear to have been favorable to the preservation of organic remains, as only small fragments of an encrinus, the vertebræ of which have a cinquefoil perforation, and terebratulites, and some indistinct traces of other bodies, are found in it.

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* Perhaps they are the same substance with the iron which it contains, in a different state of oxydation.

† The limestone as well as all the beds of the whole formation including the blue clay, have a tendency to a cubic fracture. The upper surfaces of the limestone beds are often crossed by two sets of parallel fissures dividing it into square pieces easily separable. Where the highly coloured beds abound, as on the Pulcovca, the quantities of red, green, yellow, and grey cubic fragments, which are often mixed together, resemble the tesseræ of a Roman tessellated pavement.

In the quarry at Alexandrovsky, close to Tzarscoe Celo, thin seams of brown clay alternate with the beds of limestone. In this quarry has been found, though but rarely, a body supposed to be the head of that encrinus whose remains are found sparingly in the neighbourhood. It is a sort of irregular polyhedron, the angles of which are marked with treble ribs, and the faces slightly fringed with lines issuing from those ribs.* It has been called E. Paradoxus.

Sometimes the limestone of the upper beds is of a dark red colour, in which case the orthoceratites and other animal remains are often white. I have never seen them so in fresh specimens, which are as red as the rock they come out of, but only in places which had been many years cut and used as marble, which its superior hardness and compactness qualifies it for. I cannot therefore answer for their colour on being taken from the quarry, but it is not impossible that the organic remains lose their colour on exposure to the air, as is the case with those of the black marbles of Kilkenny in Ireland, and Caermarthen in South Wales. These red limestone strata may be examined with great ease on the summit of the cliffs along the left bank of the Ishora, from the quarries opposite Cordelova to Podolova. These, as well as the purplish beds, have a texture sometimes crystalline, and the cavities are lined with minute cubic crystals of brown spar, of a red colour, together with well defined nail-headed crystals of white calcareous spar. The brown spar frequently encrusts the orthoceratites, and though forming a mass by no means compact, is of considerable hardness.

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* Bodies much resembling those here described, are figured in the plates which accompany Mr. Cumberland's account of the fossils and strata near Bristol. Geol. Trans. vol. 5. pl. 2. f. 8. &c.

The highest beds of the limestone, and which are at the same time at the greatest elevation above the level of the sea, compose the hills of Doudorof and Taply Sad. They are dry and sandy, of a pale straw colour, much resembling that of the English and Irish magnesian lime. The cavities which it contains are lined with very perfect crystals of white calcareous spar, and often with brown spar and pearl spar, of a pale, or sometimes of a bright yellow. It contains but very few organic remains; and those which are found in it are not common in the lower beds. I must particularise

A very large helicite, found by Mr. Havenschild, near Gatchina, in whose collection it now is.

A species of elongated terebratulite, never quite perfect.

A circular indented body, probably a fungite, the nature of which I cannot exactly ascertain, which I found near Poudost.

Hysterolites, sometimes with wrinkled edges. These are found in the other beds, but rarely.

Entrochi, very rarely. I found them at Skoovitza.

It is evident that the summits of Doudorof and Teply Sad are only outliers or portions of these upper beds which have perished, the fragments of which are found scattered over the plateau, especially towards Gatchina.

The heights of Tocotela and Paiola, which connect those hills, and those of Shoulcova, which are but a prolongation of them to the eastward, partake of the same nature.

Where the upper beds of the subjacent stratum are sandy, the limestone is also sandy to a great degree.

Hippurites and fungites, of small size, are not rare; in a few places they are mixed with small corallines and terebratulites, and joints of encrini in a confused mass. This resembles much some other limestones of the interior of Russia.

The strata of the limestone are seldom above half a foot in thickness, and although, where tolerably solid, it is raised in blocks of a foot and a half, yet the lines of junction are always easily to be traced. Their general position throughout the country varies but little from the horizontal, except in a few cases, which will be hereafter specified.

In the cabinet of the Mineralogical Society at Petersburg, are two small specimens of galena enclosed in a mass of pyrites, said to have been found in the limestone: place unknown. Pyrites itself occurs but rarely in this stratum.

Copper was formerly dug for at Doudorof: I could never find the precise spot, but suppose it to have been near some pits at the east foot of the hill not far from Varexila. A specimen of the green carbonate is in the cabinet before mentioned.

This limestone is called *Pleta* by the Russians, and *Pääs* by the Fins. Its principal mass occupies the great plateau or table land of the central part of Ingria, as described in the beginning of this memoir: its outcrop running just within that of the intermediate bed, which may be traced all round it, except where covered by gravel or bogs. It is remarkable, that those denudations which penetrate farthest within the outlier of this mass, shew the subjacent intermediate bed in its thinnest state, while round the edges, and in its outliers, it nearly equals the limestone itself in thickness.

It is said to contain magnesia as a constant ingredient, and the appearance of many of its beds agrees with that of similar limestones in Britain. Its Flora differs greatly from that of the other soils, and may even serve as a help to the geologist. It is marked, even to the beginning of November, by the purple flowers of the Geranium cicutarium, by which I have often distinguished it; the streams are accompanied by the beautiful tufts of Anchusa officinalis, Polemonium cœruleum, Aconitum lycoctonum; the woods contain fewer firs, and in some places many wych elms, as on the Tosna.

The only outlier of this stratum, with which I am acquainted, occurs on the brook Pulcovca, above the village of Pulcova. Although its outcrop occupies but a small space, yet it may be satisfactorily traced by means of the marked character of the bituminous clay which supports it. As certain irregularities of dip, for which this spot is remarkable, affect equally both strata, I shall leave them to be described together hereafter.

I must also notice a tract on the upper part of the Ishora, where for the space of eight or nine versts at least the limestone fails, and a red sand rock, sometimes approaching to the character of red marl, fills up the interval.* The last place on ascending the course of the Ishora where the limestone appears *in situ,* is in the bed of the river, a little below Pilny Milny, whence it is dragged up in considerable quantities. I cannot decidedly name any spot where it may be seen *in situ* on the other side of this tract of sand, but on the road to Anteleva from Gatchina, and on the hills behind Lukozy, the quantity of fresh fragments of limestone is such that it must be in the neighbourhood. The rising level of the country favours this supposition; but the valley is too much covered with alluvia to allow of accurate examination.

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* I was not able to decide satisfactorily whether this red rock was a protrusion of the intermediate bed, or an outlier of the red ground of the interior of Russia, incumbent on the limestone. Its lying at higher level than the limestone at Pilny Milny, favours the latter supposition.

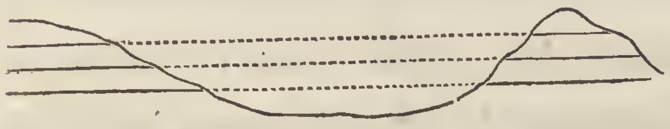
DILUVIUM.

Having thus described all those formations which occur in this district, and which belong to the class of Antediluvian depositions, the next which presents itself is that which is properly called Diluvian, and which, in contradistinction to the more modern accumulations or Alluvium, may be termed Diluvium or Diluvian gravel, by which latter name it has been long known, at least in this country.

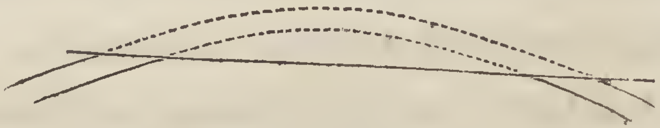
I need not say what is intended by this term; it is meant to express that superficial deposit which covers every thing, and is composed of almost every thing.

Its composition and thickness are very various: the latter amounting to thirty, forty, or even fifty feet. In some instances it

The protrusion of an inferior bed through a superior one, where entirely owing to an elevation in the strata, independent of any denudation, is a circumstance of frequent occurrence, and which it is absolutely necessary to distinguish from the appearance of subjacent rocks, laid bare by simple denudation, without change of dip in their stratification.



Denudation.



Protrusion.

appears to form entire hills, as at Penty, &c. It is usually thickest in the vallies, or on the flat summits of some of the hills. Its composition, much as it differs in different places, may be considered twofold; first, as the debris of rocks upon which, or in the neighbourhood of which, it is accumulated; secondly, as that of a set of rocks totally foreign to the country, the analogies of some of which have been recognized *in situ* at a vast distance, while others remain yet to be identified.

The principal foreign ingredient is a granitic sand, from which it is seldom perfectly free. In some parts, particularly on the right bank of the Neva, it is a pure granitic gravel or sand, partly derived from the same source as the primitive boulders themselves, and deposited at the same time with them; partly from the daily decay of those blocks from the action of the weather. This character becomes stronger on approaching the borders of Finland.

Parts of the country north of the Neva, and the environs of Peterhof and Pavlovsk, are covered with a superficial sand derived principally from the sand of the *intermediate bed*, which it either immediately covers, or abounds in the neighbourhood. When it lies upon that sand, where the latter, (as it is in many places, especially beyond the Neva,) is perfectly loose and exhibits no signs of stratification, it is extremely difficult to distinguish them, except where the presence of boulders, or rolled fragments, removes the difficulty. I am willing to confess that some parts of the map, as I give it, may hereafter be found inaccurate as to the boundaries of the intermediate bed on the Carelian side of the country, owing to this circumstance: yet where the two sands are perfectly alike in colour, and without coherence, when the upper part contains no boulders, and the lower no shells, we must have some very infallible criterion to be able to distinguish them.

The clay district is usually covered by a yellowish sand, which I conceive to be principally formed in the same manner as that above mentioned. It is sometimes ferruginous, as on the first hill on the Wyborg road; sometimes rather argillaceous, as on the banks of the stream that flows through Coupchina, and on the hill of Penty. Its most argillaceous form resembles the blue clay as nearly as the sandy form does the sand *in situ*; and is equally difficult to distinguish from the original formation. On the Tzarcoe Celo escarpment it is used for bricks, and these, as well as on the cliffs opposite Cordelova, covers the upper beds of the Pleta limestone. This occasioned its due share of difficulty in making out the structure of the country; till, happily, in the last mentioned situation, I found rolled pieces of granite and other rocks buried in this clay, which, it was then clear, could only be a superficial or diluvian deposit. The decayed felspar of the primitive boulders may perhaps enter into the composition of this argillaceous variety, as the sand formed by the disintegration of their quartzose and micaceous particles does into that of the sandy one.

That which lies above the limestone is a light brown earth, containing fragments of the subjacent rock, though in general in a very small proportion to the primitive pebbles. Its thickness is sometimes very considerable, particularly on the flat tops of the hills; at Crasnoe Celo, &c.

In the country immediately south of Petersburg, behind the bank of gardens on the left of the road to Strelna, the diluvium consists of a whitish dry clay, sometimes slightly sandy, lying in beds or layers of half an inch or an inch in thickness, to the depth of twelve or thirteen feet. They are nearly horizontal, except that the upper layers seem to follow the outline of the present surface of the earth, and where they join the vegetable mould are rather disturbed in their position. This however may be the effect of cultivation, as the soil is extremely shallow, (Plate 29, fig. 3.)* This is very well seen immediately below the gardens of a great house, formerly belonging to Count Czernicheff, on the Peterhof road, where the banks of the stream Coirovca present some excellent sections on both sides of the valley in which it flows. They are remarkable, not only for these layers of diluvian earth, but also for some of the best examples of the veined clay, described in an early part of this paper. Between the two formations occurs a bed of pebbles, eight or nine inches thick, agglutinated together by a ferruginous sand. This bed, though it does not form a hard stone, is yet solid enough to project beyond the softer substances, both above and below it, and also to fall in large pieces to the foot of the cliff, which may be from fifteen to twenty feet high, without breaking. These pebbles being primitive, both this pseudo-conglomerate, and the clayey layers above it, must be referred to the formations I have called diluvian. It can excite no wonder that a diluvian deposit should be stratified, although it is but rarely their stratification is distinctly perceptible; a circumstance which is probably owing to the purely mechanical nature of the deposit, the comparative rarity of chemical combinations on the great scale since the formation of the solid strata being notorious to every geologist. To this cause also, as well as to their hasty accumulation, may be referred the looseness and want of coherence in the diluvian formations. On the Crasninca, where the layers of clay are grey, or brown and white, and the rolled pebbles absent, it seems difficult at first sight to believe that it is not some variety of the intermediate bed, in its place above the blue clay. They continue every where along this line, immediately under the soil, to some distance beyond Peterhof, where they cover the sandstone of the intermediate bed. The outcrop or termination of which towards Strelna is so covered up by them, that I am not satisfied as to the exact point where it should be laid down; although, as the same diluvium covers the veined clay again on the Ivanovca, and occurs on the Ligovca, we may place it perhaps in the neighbourhood of Strelna without much error. The increase in elevation of the bank about that place would favour this supposition.

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* See Sketch of the clay veins on the Coirovca.

The hills of Khamouzy, Coirova, Penty, and the ridges which connect them with that of Pulcova, shew only diluvian gravel down to their foundation, although their elevation is very considerable.* It is possible that the hill of Pulcova contains the extremities of the Pulcova outlier, but nothing is apparent except diluvian gravel. The deep gullies and cliffs of the streams of Great and Little Coirova, which unite and form the Coirovca on issuing from the hills, are hollowed out in diluvium to two-thirds of their depth, and barely one-third at the bottom is scooped out in the blue clay.

This gravel in like manner reaches up to the foot of the ridge of Shulcova and Doudorof (Plate 30), and is spread over all the rising ground of Carlina behind Tzarscoe Celo; it thus so completely obscures the junctions of the limestone and subjacent rocks, and the shape of the ground is so calculated to deceive by presenting escarpments where there are no outcrops, and no escarpments where it conceals a considerable outlier, that I cannot give the outlines of the strata from Cargasary to Tzarscoe Celo as accurately determined, though they cannot be far wrong.

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* The height of the hill of Khamouzy would lead to a suspicion that there existed in it an outlier of the limestone, or at least of the intermediate bed, which is seen at the mouth of the denudations of Tarelova and Remeleva, in the escarpment opposite. The hill being thickly wooded and presenting no sections, I must leave it for the present as a point meriting further investigation.

The most striking phenomenon attending this branch of geological research, is the enormous quantity of boulders, or large rolled blocks, found either on the surface of the soil, or half, or entirely buried in the diluvian gravel, of which they must be considered as members. I cannot pretend to enumerate all their varieties; the following are the principal.

Primitive Rocks.

Large grained glandular granite, containing much black hornblende and red felspar: much used for ornamental purposes when sound, but in it general disintegrates easily by the action of the atmosphere, crumbling between the fingers without difficulty. Some of these, though retaining their upright position, are cut down and quarried for the gravel they afford for the roads: they are sometimes found in a rugged heap of gravel, and their surface in general retains little of its waterworn smoothness.

In situ; Baron Nicolai's quarries near Wyborg.

Rolled; passim; perhaps the most common species: coarse grained gneiss or granite slate, grey and red, with iron.

In situ; Imatra, and interior and western parts of Finland.

Rolled; frequent near Petersburg.

Yellowish green felspar rock, with garnets of large size.

In situ; said to be so between Kexholm and Cerdopol.

Rolled; near Strelna.

Small grained grey granite, hard, often irregularly laminated.

In situ; unknown.

Rolled; common.

Red felspar, thickly spotted with hornblende. A handsome stone.

In situ; Borgo, in Finland.

Rolled; Moscow road, one verst from Petersburg.

Dark granite, with iridescent felspar. When the felspar is well crystallized, the colours range themselves round the edges of it, if cut transversely: the blue in the centre, the green and yellow round it.

In situ; unknown. That of Norway is of a whiter colour.

Rolled; Peterhof.

Black mica slate, with crystals of staurolite—rare.

In situ; said to be so near Cuopio in Finland.

Rolled; near the Moscow gate.

Hornstone, or coarse jasper, red clouded with yellow.

In situ; unknown.

Rolled; I have seen only one large block on the shore close to the summer-house at Becova.

Basalt.

In situ; said to be in the north of Finland, Lapland, and Norway.

Rolled; one small fragment of a pillar was found on the Moscow road, and is in the cabinet of the Mineralogical Society at Petersburg.

Secondary Rocks.

Limestone of the country; sparingly; only the hardest varieties, and never far from the same stratum in situ.

Sandstone of the intermediate bed; very sparingly, in various parts of the country, and only the hardest sorts.

Green chamite bed; of the same; along the Tzarscoe Celo escarpment.

Pale brown chamite bed; on the summit of Shulcova hill; much weathered: also on Penty.

Hard sandstone with large chamites; near Anteleva, in the quarry of Repolova. In situ only on the Tosna.

Rolled masses of slaty clay; upper beds of the same; only in a ravine a little west of Samsonovsky, on the Ishora.

Doubtful.

A red sandstone, which resembles that of the neighbourhood of the Lake Onega; sometimes much coarser and larger grained; almost to be called a conglomerate. As decided boulders of what is called in England, old conglomerate, are found (though rarely characteristic) on the banks of the Volga, I am inclined to refer these to the same class of rocks.

Common on the Moscow Road.

It is evident that all these rolled stones may be found in any part of the country, although we cannot be sure of finding them in any particular spot. I have therefore mentioned only such localities as happened to be known to me.

On meeting with these blocks of stone scattered over the face of a vast extent of country, and usually lying on rocks of a nature totally different, it naturally becomes a matter of inquiry, whence they were derived. Without entering at large into the discussion of this interesting question, which is one of the most important and wonderful that geology affords, it will be sufficient to state a few particulars with regard to their situation in the neighbourhood of Petersburg.

By the specification of the principal varieties which I have attempted to give above, it will be seen that all the primitive boulders, the analogues of which have been recognized *in situ*, appear to have been transported from the north. They are scattered universally over hill and dale; on the highest summits of the hills, and on the shores, and under the waters of the gulf; and are found not only on both sides of the Neva, but far to the south, to the east, and to the west of the boundaries of the district I am describing. Their waterworn surfaces, their enormous size,* and the remoteness of what, without a great stretch of credulity, may be believed to have been their ancient seat, seem to leave no other supposition to account for their appearance in their present situation, than that of their being the gigantic pebbles, rolled and accumulated by the greatest aqueous revolution to which this globe has ever been exposed, the Mosaic deluge, of which they furnish the most striking of the material evidences. This is not the place to enlarge upon this subject; but I may add that the environs of Petersburg, as well as every other country, shew those traces of the superficial action of vast currents of water, which can only be attributed to the same cause. I need only instance the Ropsha and Crasnoe Celo denudations, and the numerous combes and vallies now destitute of water, along the edges of all the escarpments. Such examples occur every where; but they are more easily remarked in secondary than in primitive countries, owing to the greater softness of the materials.

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* The celebrated block out of which the pedestal which supports the statue of Peter the Great, in the Isaac Place, in Petersburg, was a rolled boulder of the red Finland granite. It was not brought, as has been asserted, from Siberia, nor, by human means at least, from Finland; but was found, among many others of smaller size, in a bog between Petersburg and Cesterbeck. It was diminished two thirds, before placing the statue on it.

A boulder of great size supports a summer-house on the sea shore at Becova, which is ascended by a ladder.

The blue clay, is never sufficiently solid to admit of being rolled into pebbles.

The intermediate bed occurs rolled but seldom; never on the Carelian side of the Neva: on the Ingrian side are found sometimes small rolled fragments of the sandstone which is *in situ* between Peterhof and Oranienbaum, but in no great quantity.

One of the most remarkable circumstances respecting the boulders of this stratum, is that rolled pieces of the smaller grained chamite beds are found on the summit of a steep ridge forming the extreme point eastward of the heights of Shulcova. They lie principally on the western brow of the hill, where it overhangs a deep ravine filled with an impassable and mossy bog, and looking towards Doudorof. The great elevation of this ridge, which apparently yields only to Doudorof and Teply Sad in height; the geographical distance from the nearest point where the chamite bed appears *in situ*, which is at the Slavenca quarry, or possibly on the Coshelevca;* and the great thickness of the limestone in that part of the district, make it a question of no easy solution, how rolled fragments of a rock three hundred feet or more below that on which they are found lying, could ever have arrived at their present situation.

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* I have been told it exists there *in situ;* but I never could distinguish it myself, otherwise than in rolled pieces. This stream is overgrown, and almost buried in tangled brushwood, which renders the examination of a small protrusion of the intermediate bed through which it cuts, not only difficult of access, but unsatisfactory where accessible. See the conclusion of Mr. Weaver's paper, Geological Trans. vol. 5.

Their present perishable appearance is not so great an obstacle to this supposition as might at first be imagined; since this rock is extremely hard when *in situ*. The difference of hardness and colour observable in the rolled fragments may therefore be the effect of weathering.

On the Ishora, the rolled pieces of different varieties of the intermediate bed become more frequent. In a dry ravine close to the village of Samsonovsky,* are found in the diluvian gravel, almost every description of boulder known in the country. Among them are round balls of the grey slaty clay of the upper part of the intermediate beds, a substance which hardly seems ever to have had sufficient solidity to withstand the shocks to which it must have been exposed in the diluvian current, especially in the company of the much harder pebbles by which these masses are surrounded. Since the period of their being lodged in this spot, they seem to have undergone considerable disintegration: although their outline is entire, as they are seen wedged in with the rest of the pebbles composing this gravel, not one of them could be taken out whole; they are all now splitting in the direction of their laminæ, and would fall to pieces as easily as the small rounded fragments of the same substance which are found in the brooks immediately beneath their parent rock.

Near Anteleva, the gravel pits of Repolova deserve attention for the fine blocks of the large chamite bed which they contain, and which have been already described.

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* In Finnish *Oloseen Mekky*. As a great many of the villages retain their old Finnish names, even although they have received others from the Russians, I have thought it adviseable to give both, as the Fins will not always acknowledge the Russian names for villages inhabited exclusively by their own nation.

Near the village of Lukozy is a vast accumulation of fragments of the limestone of different varieties.

The limestone boulders are never found north of the outcrop of that stratum whence they are derived, and rarely on the table-land itself. Such as are found there are chiefly fragments of the harder varieties, which occur *in situ*, in the hills of Doudorof. They are more numerous about Gatchina, and encrease in number along the Ishora, and in general towards the south. On the surface of the limestone plateau, particularly south and west of the upper lake of Doudorof, are several long low ridges, which appear to be entirely composed of heaps of rolled pebbles of various descriptions. They are on a large scale, exactly like what are deposited by counter currents and eddies in running water.

At the quarries near Mishkina, belonging to Count Camerofsky, on the escarpment between the Ishora and Tosna, I have seen the surface of the limestone, when scraped bare of superficial accumulations which are ten feet thick, presenting hollows and steps from one bed to another, the edges of which are all rounded as if waterworn. The diluvium in this instance is entirely free from stones.

From the situation of the parent rocks of such of the primitive boulders as yet have been identified, and from the increase in quantity of the secondary pebbles on approaching the south, it seems that the great debacle, or stream of transportation, came from the north; while, from the great height at which the rolled blocks are found, it is evident, not only that portions of rocks, whence they have been brought, once existed at a higher level, but also that they were deposited in their present situation before the excavation of the Gulf of Finland and the vale of the Neva. These great denudations, together with those smaller ones which open into them, were not hollowed out till the diluvian waters began to draw off and drag the slopes of what had been the bottom of the ocean. The heavy blocks had already settled, and the streams carried back with them only the softer materials. This accounts for the seeming incongruity in the direction of the diluvian currents; just as a great wave of the sea will transport pebbles large and small in a great body in one direction; then, retreating, drop the heavier and scoop channels in the lighter materials which it has itself just deposited, and in whatever is below them; into some of which channels a few large pebbles fall back again.

This also explains the remarkable circumstance of the existence of large deposits of diluvian gravel on the summits of insulated hills, as at Doudorof. The gravel has been equally deposited at first on the surface of the strata, by the great debâcle; and as it draws off, certain portions of the solid strata with their new diluvian covering have been removed, and other portions of the same strata, insulated or connected, have been left with whatever was above them. I imagine the eddies, currents, back streams, and whirlpools of the diluvian waters to have had as much share in the shaping of the surface of our present earth, as any supposed difference of hardness between one portion of the same stratum and another. The fragments which remain to attest the solidity of many vast masses of strata which have been broken up and carried away, seem to countenance this supposition.*

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* This part of Russia appears to be as poor in the remains of quadrupeds usually found rolled in diluvian gravel, as other parts of the same country are rich in them.

I can only mention a scull said to be that of a rhinoceros found in Petersburg, in the mud of the Moika canal, in 1818; now preserved in the Academy of Sciences; a tooth, of doubtful origin, said by some to be that of a wild boar, (an animal now a stranger to this climate) found near Pavloosk, now in the cabinet of the Mineralogical Society; and the report that an elephants tooth had once been found near the Moscow road.

ALLUVIA; or POST-DILUVIAN FORMATIONS.

The formations which I comprehend under the term alluvial, in its most confined sense, now claim our attention. As they are contemporaneous, their position can give no system of classification; I shall therefore begin with that which resembles the antediluvian formations more closely than the rest.

Tufa or Tuf, a calcareous deposit from the waters of lakes or rivers rising in or flowing over a calcareous district, is found in several places on the Ingrian side of the Neva. I shall only mention Gastilitzi, where it forms arborescent incrustations resembling corals, to which moss probably gives their peculiar shape and appearance: Ropsha, where the waters of the Strelca and tributary streams abound in stalactitic depositions; Poudost, between Doudorof and Gatchina, famous for its quarries; and Anteleva on the Ishora, where the Tuf occurs in the form of distinct balls, of the size of a large turnip, being concentric crusts of calcareous matter adhering to a nucleus usually very small in proportion to the entire mass, and which is commonly a pebble fallen from the diluvium on the river side.

A little above the village of Poudost, situated on a stream which rises near Kipen and falls into the Ishora at Gatchina, is an open valley, about a verst in width through which the river flows. For the space of two versts it is accompanied on each side by calcareous depositions, which form also its present bed. There are some considerable quarries on each bank, which are now worked chiefly for lime: but which have formerly furnished much stone for building. The colonnade and porticos, if not the whole of the Cazan Church at Petersburg, the Palace at Gatchina, the colonnade in the garden, opposite the north front of the palace at Peterhof, and many smaller ornamental buildings which decorate the environs of Petersburg, are constructed of this stone. Though coarse and porous, it is the best building stone in this part of Russia: its colour being a fine yellowish white, and its substance light and easily worked. Unfortunately it is hardly durable enough to withstand the vicissitudes of spring or the severity of winter in a climate where the thermometer often ranges 24° of Réaumur, up and down, partly above the freezing point, partly below, in as many hours. It may be added, that stone building is as yet so very rare in Russia, that this material is neglected in many other situations besides this.

I have only been able to find two species of shells, sometimes preserved in this stone, never in great quantities. They are a species of the helix and a buccinum, both fresh-water varieties, and yet to be found in a recent state on the banks of the river. There is a ford which crosses the river nearly in the middle of the valley, formed by two ledges of this rock over which the water falls as clear as crystal. In this situation they seem at first to be rocks of the soil, and any thing but recent depositions. The quarries and the flat land in which they lie are now never covered but by high floods. Trees and thickets are scattered over the surface of the tufa, remarkable for some handsome species of Campanulæ and some dwarf willows uncommon in other parts of the country.

The greatest depth to which this bed has been quarried is only six feet; it probably does not reach much lower, although the substratum is not laid bare.

It is remarkable that, of all the waters of this country, those which deposit tufa, are apparently the purest. Perhaps the lime is held in perfect solution, and the sediment is to be considered as partly of chemical, partly of mechanical origin. In great floods, the quantity of water would be encreased and take up more lime, which it would deposit as it lowered by evaporation. Hence the great purity of this limestone and its fitness for burning into lime.

The whole valley from Skvoritza, down to Poudost, or even beyond those two places, seems as if it might formerly have been a lake, which by the raising of its bed had run out towards Gatchina.

The next important member of the post-diluvian formations occurring in this country are the great bogs, which are of vast extent, but in general of no great depth. They exactly resemble those in England, except that there is less mountain peat, most being of the coarser kinds usually found in vallies, and that they are more covered with wood. The firs, birch, and alder, and sometimes aspen, arrive at various heights according to the wetness or dryness of the bogs. Some, as those near Shulcova and Carlina, are so wet as to resemble a half liquid black paste, scarcely supporting even the common mosses from which it derives its origin. Many are absolutely impassable before the middle of winter. The dried bogs support a kind of coarse grass and most of the herbaceous plants peculiar to woods.

It is not yet used for firing, but some English farmers have proposed it as a good material for burning bricks. Of late some attempts have been made at draining.

The marsh land or alluvia formed by earthy depositions at the mouths or on the banks of rivers, lakes, &c. has already been noticed in the general description. It exists only on the shores of the gulf and in the mouth of the Neva.

The sand thrown up by the sea may be noticed in this place, because it covers, at a small depth, the blue clay which may be seen here and there on the Oranienbaum shore. Many substances are dug up in the alluvium, coated with phosphate of iron.

[*] Within each bog, usually near the centre, is almost always found a lake or small pool, gradually filling up. In many cases, as at the Finnish lake Lindo Jervy, in the woods of Riabova, the spot where land ends and water begins is not to be determined, except the gradual dwindling of the trees is taken as a criterion. Stunted birch and alder bushes grow into the water, and encroach every year on the retreating waters of the lake. Some such cause may be connected with the quantities of old wood found in many places beneath the superficial soil, as on the lower Coirovca and Crasninca, in a soft and moist state, dark brown, and easily cut in all directions with the spade, like cheese.[†]

Blocks of a hardish, white, rugged stone, are found on the banks of the Tosna: they resemble tufa, but I cannot discover it there in situ.

It remains for me to describe more minutely a few of the more remarkable spots situated within this district, and to which I should wish to draw the attention of any future geologist who may happen to visit the environs of Petersburg.

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[*] Phosphate of iron is not the only alluvial metallic substance found in this district. The waters of this neighbourhood, (especially of the sandy part of it) are very commonly impregnated with oxyd of iron, a character by no means unusual throughout all the north of Russia. This iron is deposited in great quantities at the bottom of almost all the lakes, bogs and rivers, on the Carelian side of the Neva, more sparingly on the other. Large masses have been raised even out of the bed of the Neva itself. It is in the state of bog or marsh iron ore, and supplies some iron works. Where the waters are very strongly charged with iron, they communicate a bright red or orange colour to pieces of wood which they meet with in their course: the iron itself being often deposited in the interior of the branch or between the bark and the wood, by very slow infiltration. This is a beautiful instance of what is vulgarly called petrifaction. Branches of the birch afford better examples than those of any other tree.

[†] A layer of old wood is also frequently found under the soil throughout the flat country east of Riabova.

The first excursion he should make is to the valley of Crasnoe Celo. There, in the three ravines which cut the western side of the valley, passing through each of the three villages of Pavlovsky, Bartashinsky, and Colomensky,* sections of the three strata of limestone, black clay, and blue clay, give a perfect idea of the regular and undisturbed position of the principal mass of the limestone formation and subjacent beds. The limestone fossils are also abundant and well preserved in this neighbourhood. The lakes of Doudorof present but little interest in themselves, but on the eastern bank of the upper lake rises the hill of Teply Sad, covered with a fir wood, remarkable for the beautiful and rare plants to be found beneath its shade. East of this hill, a branch connects it with Doudorof, a hill of equal or greater elevation than Teply Sad, and consisting, like it, of steep terraces of the upper limestone beds, rising from the plateau formed by the lower ones. The escarpments of these terraces, especially the precipice west of the Fin church, looking towards Teply Sad, are on a scale far surpassing what the general view of the country gives reason to expect. The summits of this hill are very peculiar in their form, and are very well laid down in the great map of the environs of the Capital. They appear to have been formerly covered with wood, as Teply Sad still is. In every hollow is seen a small pool or lake, or the traces of one. The branch stretching to Shulcova, and the detached ridge opposite its termination, possess the same characters, and are almost inaccessibly steep. The rock appears every where through the soil, and in the latter instance there is reason to believe it is highly inclined,* though no good section can be obtained. These detached summits, Cargasary, Teply Sad, Doudorof, and Shulcova, all possess a similarity of character sufficiently striking even at first sight.

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* These three villages, together with the heights on which they are placed, are called collectively by the name Crasnoe Celo, or Red Seat (red and beautiful being synonymous in Russian). The custom of calling a number of villages or hamlets by one common name is very general in this country. Thus half a dozen, having each distinctive appellations, between Doudorof and Tepley Sad, go by the name Paiola; the hamlets called Toxova extend several miles; three villages compose what is called Cabozy; three more Tocotela, &c. This is perplexing to the stranger, but is now in some degree remedied by the erection of posts, on which the name of each village or hamlet, however small, is written up at each end of it, together with the name of the proprietor, and the number of houses or inhabitants.

The ravines of Great and Little Coirova, especially that which runs through the dell in the old Solticof garden, also the lower part of the Coirovca and neighbouring streams, should be visited for good sections of the blue clay, and in the localities mentioned in their proper place, for examples of the clay veins.

All the streams along the eastern escarpment merit particular attention: the Pulcovca, Couzminca, Goumolosarka,* Coshelevka, Popovca, Slavenca, Ishora, and Tosna, should each be followed up from the places where each respectively quits the escarpment to where they rise to the level of the land around them. The Pulcovca, as exhibiting certain remarkable phenomena connected with an outlier of the limestone, I shall leave to be more particularly described at the end. The Couzminca is remarkable for the total absence of any thing but blue clay in its banks, since it flows within a short distance of a considerable body of limestone on either side; the Goumolosarka for its organic remains; the Coshelevka for a small burst of the black clay which pierces the limestone during a short space, but which cannot be seen without walking in the bed of the stream. The Popovca has already been mentioned; its banks are very picturesque, and abound in beautiful flowers; and afford an instance of disturbance on the left bank, a little below the village of Popova. Two masses of limestone strata are divided by a fault or slip; the stratification of the portion on the left is contorted, that on the right regular.

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* A disposition of this rock to separate into cubic fragments has already been noticed. In this instance, the western escarpment shews the rock peeping through the soil; no stratification is visible as in the case of the precipices at Doudorof and similar situations, but what appears to be the back of the beds is seen with its remarkable cross fracture dividing it like a network of irregular veins. The slope of the back of these beds, if I am correct in terming them such, coincides with that of the hill itself.

* The Russian name for the rivulet which waters the village of Houmolosarry. This name is Finnish, but the Russian alphabet being unable to express the sound of the letter H as the natives are to pronounce it, they have prefixed their usual guttural, which is unknown to the Finnish language, and added the common Russian termination.

The Slavenca is worth visiting for the chamite beds, which are seen in perfection in a quarry on the right bank of the river, near the brow of the hill. The road from Grafsky Slavenca on the opposite side of the valley, leading through Popova to Tzarscoe Celo, passes down a remarkable dip of the limestone, which I suspect turns up again near the Popovca bridge. In the basin formed by its hollow back, is lodged a deep and impassable bog.*

The Ishora has been sufficiently spoken of to give an idea of the importance of the sections on its banks. Besides the occurrence of the red sand, which, as has been stated, bursts up from beneath the limestone from Pilny Milny, below Anteleva, and is continued to near the Gatchina road, and which is best examined near Verly, a smaller accident of the same nature is found lower down near Podolova, where the blue clay bursts from under the sand rocks. Of this I have given a small plan. The whole of this river is interesting, and the environs of Podolova and Cordelova even picturesque. Between Cordelova and Pilny Milny, I have not been able to inspect it myself. Fedorovsky is a high eminence of limestone, bounded by the sandy denudation of Pavlovsk, but offers nothing remarkable in itself.

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* At the junction of the Popovca and Slavenca below the village of Pezelova, the blue clay is seen *in situ*: the sandy banks and road sides above it, shew evident marks of the intermediate bed in situ, which may be traced on two sides to its place, dipping under the limestone on the Slavenca as well as the Popovca.

Limestone pebbles abound here, which seems as if it once extended across, i. e. above this valley; it is not met with in situ till near the limekilns of Ontolovo, on the Slavenca, (not to be confounded with Anteleva on the Ishora, though both places are often spelt alike in the Russian maps, owing to the confusion in that language both in writing and pronouncing the letters A & O). On the Popovca are also found a sort of geode, of an elongated cylindrical shape, rounded at the ends, usually with one or two compressions on the sides.

But by far the most romantic of all these streams is the Tosna, whose banks present at once landscapes to the painter, beautiful and rare flowers to the botanist, and perfect specimens of organic remains, together with interesting sections of strata to the geologist. From the large and flourishing crown village of Nicolskooy upwards, the banks attain a height of about two hundred feet, the lower part of which consists of naked cliffs, and the upper of hanging woods. At the village blue clay is seen *in situ*, and a little higher up, are cliffs of it 30 or 40 feet in height, perhaps the greatest strength in which it is shewn in any natural section. The top of one appears capped with red sand, under which, a few yards further on, the blue clay sinks to rise no more. The different strata of the intermediate bed now occupy the banks of the river for a space of three or four versts or more; its subordinate beds are nearly the same as on the Ishora, but the entire mass is of much greater thickness. The bituminous clay beds are scarcely discernable. The red chamite bed is in great abundance, sometimes very hard. The larger chamites are found in a soft white or yellowish sand, which adheres to the lower part of some of the harder red strata, and when viewed from beneath some overhanging masses of rock, appear like black spots, the nature of which would not readily be conjectured. This bed is rather difficult of access, but its true nature cannot be seen well without examining it *in situ*, as it is not sufficiently coherent in this place to fall in solid fragments like those of the red chamite bed. This spotted surface might be taken at a distance for a conglomerate. Whence those fragments of this bed which are found at Repolova have been transported, it is impossible to say, but their superior hardness makes it impossible that they should have been brought from the Tosna,* as well as their situation, which is nearly east of that river, the general diluvian current appearing (as has been stated) to have come from the north. All this sandstone on the Tosna, though soft, shews distinct traces of the globular or botryoidal structure, which however is most apparent in those beds or fragments over which the water flows. The strata are very nearly horizontal: the cliffs form perpendicular façades of rock, usually continued into the water, but sometimes skirted by vast tabular fragments of all colours.

The limestone is seen at Cordelova and along the lower Ishora, occupying a distinct terrace above, and containing trilobites and other organic remains in great perfection. Near a ruinous old house, called Gertovo, there is a ravine on the left bank of the river, where a torrent falls over a series of broken beds of limestone as regular as stairs: near this place the river's bed rises to the level of the limestone, and the sand is no more seen.

I have before mentioned a stone resembling a hard white species of tufa, which is found in large masses in the bed of the river, and which I have not been able to detect *in situ*. This is one object which I would beg to point out to the attention of any future traveller.

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* Or, to speak more correctly, from that part of the limestone strata through which the river Tosna now flows.

I have given views in Plate 31, of this interesting and romantic glen, taken from the grounds of an old deserted country house on the right bank of the Tosna, the situation of which, placed on the summit of the rocky bank of the river, and surrounded with hanging woods of deciduous trees, abounding in rare and beautiful plants, which feather down to the water's edge in every vacant space between the stony precipices, affords the wildest and most picturesque scenery to be met with in all the country round Petersburg; and would not be misplaced in Wales or Austria.

These, with the Pulcovca outlier, are the only places worth visiting on the Ingrian side of the Neva.* The Carelian side is still less fertile in interesting localities. The principal, however, are

The hills and lakes of Toxova, which, though it does not offer much to the lover of geology, is yet worth visiting, as the most favourable specimen of the scenery of this side of the country. I may add Riabova and the banks of the river Okhta from the gorge of Copsala to its mouth.

I flatter myself that this enumeration of the principal geological points, may be of use in saving many tedious hours of useless research to those who may hereafter visit the environs of Petersburg. In a country, the features of which, scarcely in any instance direct an observer to the spots best calculated to instruct him, and which after all, are but few in number, much time must necessarily be lost in traversing the country at hazard, and much disappointment experienced in seeking sections, rocks, &c. where they are not to be found, though sometimes balanced by the good fortune of finding them in inconsiderable ravines or banks where their existence was hardly to be suspected. Not the least evil is the enormous accumulation of diluvium so generally spread over the whole face of the land. Though not so thick as in many other countries, yet it blocks up by far the greatest number of the banks and escarpments, where it would be natural to expect the strata to shew themselves at the surface. Add to this, bogs and impenetrable forests, the distance from Petersburg to any interesting ground, bad roads and other inconveniencies: the absence of quarries, in a country where building with stone is hardly known; of gravel pits, where the roads are not *made* roads, (except with logs,) but tracks of earth, left to be beaten and formed by carriages as paths are by men; and the Russian language known to few, and its only alternative among the peasantry, the Finnish, being known to still fewer of the foreigners who visit this country.

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* It must be remembered that, however interesting some of the spots described may be in themselves, they are scattered over a very considerable tract of country. As places of minor interest, I may particularize Caporié, Lapoukhina, Gastilitzi, Ropsha, and the whole bank and gullies which intersect it between Strelna and Oranienbaum: also Pargola, and Coultoushy beyond the Neva, and the falls, as they are ridiculously termed, of the Neva itself.

Among the manufactories, the iron works of Caterinhof, at four versts from Petersburg, those of Cesterbeck and Colpina, the former at twenty, the latter at twenty-four versts, distance: the paper works at Peterhof, and the cotton works of Alexandrovsky, deserve to be inspected.

I must observe also that the sections on the banks of the rivers alter their appearance considerably from year to year: the severe frosts of the winter and the sudden melting of the snows in spring contributing to throw down and carry away large portions both of rock and soil. This accounts for the frequent landslips and fresh broken appearance of the banks of the most inconsiderable streams. Nature offers every season some new opportunities of investigation to the practical geologist in a northern climate.

It may not be amiss to add to the foregoing observations, some account of the relations which the strata of the district I have been describing bear to those of other parts of Europe, as well within the limits of Russia as beyond them.

To the north, the blue clay disappears under the overwhelming mass of granitic boulders and sand, no precise boundary being assignable to it, or to the granite of Finland, the first rock *in situ* which appears beyond it. The intermediate bed, consisting entirely of loose sand, becomes so mixed with that derived from the same origin with the primitive boulders, increasing greatly in size and number as they approach their original rock in Finland, that they are no longer distinguishable, and all trace of a decided outcrop is lost. The limestone has not yet been discovered north of the Neva. Thus, the district described in the preceding pages may be considered as comprising the most northerly border of the formation which consists of the three most marked strata of secondary rocks which occur in this part of the north of Europe; the blue clay, the intermediate bed, and the Pleta limestone.

Their progress, however, is traced very satisfactorily towards the east, beginning at Nicolskoy on the Tosna, the last point on this side to which I have followed the escarpment in the detailed survey. Although the blue clay is seen in great strength on that river, yet the general rise of the bed and valley of the Neva towards the Ladoga lake, and consequently of the valley of its tributary streams, soon cause the sand of the intermediate bed to become the lowest visible stratum. It probably crosses under the Neva a little above Pella on the left bank and below Astrafki on the right, forming, as is supposed, together with an accumulation of primitive boulders which appear to have been collected on a bar of the harder sandstone beds, those rapids commonly called the falls of Pella. The encreased rapidity of the stream is occasioned also by its being suddenly raised, as it were, on a step of this sand, independently of its being impeded by the fortuitous presence of the primitive boulders which have rolled into this principal valley or lowest trough of the district, and have been stopped by the more solid ledge of sand on which they have now settled. The same circumstance is of frequent occurrence in many of the smaller rivers round Petersburg, which consequently appear in many places like mountain torrents, whilst in others they are sluggish and muddy streams, perfectly suitable to the tame character of the country through which they flow. A sort of bar probably of a similar nature, exists opposite Schlüsselburg; the Neva flows over it as it quits the Lake Ladoga. This forms a kind of lip or edge to the basin which contains the lake, behind which is deposited the greatest part of the earthy particles which the water may have collected; hence the great purity of the waters of the Neva, and in general of all rivers at their exit from lakes. What the Neva deposits therefore lower down, must be chiefly if not entirely taken up in its own course, properly so called and not drawn off from the lake. The lake itself, at least the southern part of it, is so extremely shallow,* as to be scarcely navigable; it probably rests upon the sand, without penetrating in any part to the clay. The limestone I have not traced myself thus far, but it is visible at Poutyelova, where I have examined it, and I have little doubt of its extending uninterruptedly along the hills which skirt the valley of the Neva on this side and of its joining the Tosna with Poutyelova, as I have found it to connect the Ishora with the Tosna.

The great quarries of Poutyelova, which principally supply the capital with limestone for flags, are situated on the top of a high ridge of hills south of the Ladoga Lake, twenty-five versts south east of Schlüsselburg. The strata are remarkably regular and horizontal; and the stone differs in no respect from that found nearer Petersburg. These quarries enrich the inhabitants of the thriving crown village of Poutyelova, which is placed on the very brow of the hill in the body of which the stone is worked. The escarpment is in some places nearly perpendicular, and commands an extensive view of the lake Ladoga. Standing on this cliff, and looking to the north, it is impossible not to admit that there is at least a plausibility in the opinion, that the lake once washed its feet, and that it has since retreated, leaving the boggy plain now below it, which is yearly encreasing by a continuation of the same cause. The general traditionary idea that all the waters in this part of Russia are gradually sinking in level, (an idea which I shall not stop to examine,) tends to corroborate it. In the woods of Nazya are seen long barren ridges of loose sand, parallel both to the cliff and to the present shore of the lake, which might well be the ancient strands of the lake, left one behind the other, as it retired. This sand is very different in appearance from the true intermediate sand as it is seen in the neighbourhood. If not a sandstone, it is at least coherent, and shews the same colours, red, white, and yellow, so common on the Ishora and Tosna: in addition to which it forms several small hills and knolls of a decided character near Sheldikha, and may be seen cropping out from under the limestone on the eastern ascent to Poutyelova. The latter locality is at a considerable elevation. The celebrated canal of Ladoga, cut by Peter the Great, but now much neglected, runs through the plain below; by means of which the stone is transported to Petersburg.

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* The northern parts are very deep; but there the coasts consist of harder and older rocks and are much indented by deep bays.

The broad valley through which the river Volkhof flows to New Ladoga, here interrupts the escarpment: the limestone may perhaps appear on the banks of this river higher up, but I have had no opportunity myself of ascertaining whether it does so or not.*

The limestone hills reappear east of the Volkhof and stretch in the same direction, varying a little to the north east, towards the south of the lake Onega. The river Sas cuts through them, and its picturesque banks claim the particular attention of the geologist. The cliffs between Poulnitza and Lzy are a sandy variety of the Pleta lime, abounding in organic remains, usually well preserved. I found there, during a very cursory examination, a fungite exactly resembling those of the Tzarscoe Celo, and Esthonia; blocks full of broken encrinites, &c. resembling those of Sweden, Esthonia, the Valday hills, and central Russia; also one remarkable fossil, the nature of which I have not been able satisfactorily to determine. It resembles a fish's skin, and is coloured red and white.

South of the Lake Onega, extends a plain which is described as exactly similar to that south of the lake Ladoga. The tract between the two lakes is represented as entirely occupied by the sand, till towards the north the older rocks appear. On the river Megra, occurs a limestone containing madrepores of great beauty, which I conceive to be a continuation of the Pleta lime. It is said to occur (with trilobites, and accompanied by the black intermediate clays) near Vitegra, at the mouth of the river of that name. It probably stretches as far as the sides of the Oural chain in the governments of Archangel or Vologda; but these as yet are parts unknown.

Of the southern boundary of the limestone tract I have no very certain accounts, nor have I been able to investigate it myself. On the river Sas it is of no great breadth, and is succeeded on the south by a red sandy country resembling that on the north west of the Volkhof; it appears to pass by Chudovo, and to bound the plain of Novgorod and Ilmen. I have seen specimens of it from Seltza Posad on the Shelon, in the government of Pscov: but I cannot state with certainty whether that forms a detached body from the great mass of the formation to the north, or whether it is connected with it. In character it resembles that of Esthonia.

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* I have since heard that the limestone is seen in cliffs on the banks of the Volkhof.

Westward, the limestone stretches along the boundary of Esthonia and Livonia, occupying the greatest part of the former country. Near Fellin in Livonia, it is said to have been worked formerly by the Swedes, for the sake of lead and copper, no longer to be found there. It is continued to the western extremity of Esthonia, and passes into the group of islands of which Oesel and Dago are the principal, and in which some of its beds are sufficiently fine to be used as marble. This Esthonian portion of the limestone is famous for the superior beauty of its organic remains, especially at Lachsberg, near Reval. They agree with those found near Petersburg, but the fungites and corallines are larger and in a much better state of preservation. Boulders of it are found scattered over the central parts of Livonia, and more sparingly in the vale of Novgorod. It is connected with the Ingrian limestone by passing between the Lake Peipus and the gulf, and under the stream of the Narova, being the rock over whose strata that river falls a little above Narva.

I have above only followed this formation as far as it is known with tolerable certainty to extend in one uniform direction, and in a mass probably but little interrupted, within the confines of Russia; an investigation which at the same time will serve to give an idea of what must be its boundaries along a part of the northern and eastern borders of the Great Basin of the north. Before I am led to speak of its prolongations in other directions beyond the frontier of the empire, it may be as well to notice a few instances of similarity which exist between some of its members and certain rocks in other parts of Russia.

The red marly clay of the central governments sometimes resembles much the variegated portions of the blue clay. I will only mention Uryevetz Pavolskoy or Uryetz on the Volga, where the marl is streaked with grey, white and blue beds. This variety is common along the banks of the Volga, and of the Msta.

The black slaty clay of Simbirsk and Moscow, containing green sand and pyrites in abundance, much resembles that of the copper strata of the intermediate bed, but contains numerous organic remains and septaria, both unknown in that of the environs of Petersburg. From near Simbrisk I have seen specimens of a slaty bed, containing fragments of what resemble the broken shells of some of the chamite beds, but which are two indistinct for me to venture to pronounce them identical. I only mention them, therefore, to induce those who may have it in their power to make repeated comparisons, without which nothing in geology can even approach certainty. In the eastern part of the town of Kineshma on the Volga is a sand-pit, the sand of which is a bright yellow or white, and of a glassy appearance, like that on the Ishora. A globular sandstone, perfectly resembling that described on the Tosna, is found on the Msta, a few versts above Borovichy, accompanied by a coaly clay, in which there is much pyrites. In the neighbourhood of Nishny Novgorod, is found also a globular sandstone nearly resembling those of the Msta and Tosna except in colour, which in the former is greenish grey, in the two latter, yellow.

That variety of the limestone which is filled with broken entrochites, small terebratulites, &c. and is most common in Esthonia and on the Sas, is almost identical with the white limestone of the hills south of Moscow and of the central parts of Russia. In the limestone used at Cazan, quarried I believe on the right bank of the Volga, are small terebratulites having some likeness to those of Gatchina in the yellow Pleta. The limestone at the falls of the Msta above Borovichy, bears also some resemblance to it: more perhaps in geological situation than in outward appearance, as it lies above a series of sandy bituminous and pyritical beds which are again supported by the clay.

Before attempting to trace this formation out of the Russian territory, it must be remarked that its general line of bearing is from north-east to south-west. Proceeding therefore from the Livonian isles in a south westerly direction, we meet first with the Isle of Gothland, whose structure and fossils, especially the trilobites and orthoceratites found in its limestone, are merely a continuation of those of Esthonia. The same may be said of Oeland, and of the opposite coast of Sweden, behind which rise the primitive rocks, which thus form a western boundary of the formation. But it is remarkable that Sweden contains a great many detached districts* or outlying masses or basins, of these strata, separated by ridges of primitive country. They all agree in consisting of a limestone resembling the Pleta, lying on strata of sand and bituminous or aluminous clay, slightly differing from those of Russia. The red Pleta with ortho-ceratites, may be identified with that of Osmundsberg in Dalecarlia: the yellow containing trilobites, with that of the Isle of Gothland; the entrochites, &c. of Esthonia, with those of Scania. In many parts it is covered by flœtz trap and flœtz porphyry. I confess myself unable to trace these formations any further. I suspect their existence in the south of Norway, and their western boundary must be sought in Scotland and England; in the latter country, the transition limestone, with trilobites and orthoceratites, and its accompanying sandy and argillaceous beds are the only rocks I know that bear the least resemblance to them.* Their southern edges must be looked for along the north of Germany, the south of Poland, and Russia. The intermediate country of Denmark does not seem to present any trace of them.

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* There are those of Jetland, Dalecarlia, Nerimke, east and west Gothland, Scania, and the isles. The latter indeed is not properly speaking, a detached district, being in fact the western extremity of that which is the subject of this memoir.

The sections given in Thomson's Travels in Sweden, seem to render it probable that this formation rests immediately on the primitive rock; supposing, as I do, that the blue clay of Petersburg answers to the lower bed of the Swedish secondary strata. The apparent absence of all intermediate rocks, between the most southern known termination of the Finnish granite and the most northerly point of appearance of the Russian secondary strata, concurs with the general resemblance they bear to those of Sweden, to support this idea.

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* On comparing a very complete series which I was able to collect of this limestone, with the transition limestone of Longhope, and the environs of May Hill on the north west of Gloucester, Professor Buckland has ascertained an agreement in so many minute circumstances of the rock itself, as well as of its organic remains, as to feel the most confident assurance of their identity, the resemblance is particularly striking in those varieties of the limestone which are charged with magnesia, and the chief difference appears to consist in the accidental presence of grains of chloritic earth disseminated through some of the strata near Petersburg, such grains not being usual in the transition limestone of England.

This identity being admitted, we may expect to find in the limestone shale and slaty sandstones of the English transition series, analogous depositions to the beds of slaty clay and siliceous sand that lie beneath the limestone in Russia.

In several varieties of these latter, this analogy is faithfully maintained, but in the greater part of them a want of compactness, either original or resulting from gradual decomposition, reduces much of the sandstone to the condition of mere loose sand, whilst the argillaceous slates present an appearance of unstratified clay.

For a detailed account of these transition rocks in England, on which Professor Buckland has founded his comparison with those of Russia, see his paper on the districts adjoining to the Severn in South Gloucestershire.

I shall conclude with stating, for the information of the future geological traveller in the north, what I consider the principal desiderata in the history of the formations in the neighbourhood of Petersburg. It would be necessary to commence by visiting those localities I have before enumerated, in order to acquire the requisite acquaintance with the characters of the strata: a work of no great length of time, and which I have been the more particular in pointing out, because, were they to be blindly hunted after throughout a tract of country so generally uninteresting as the greater part of the environs of Petersburg, and which gives so seldom the least clue to its hidden treasures, not only would more time be uselessly consumed than is usually at the disposal of those who are not residents in the capital, but many would be turned back by an early disappointment from researches of the highest importance to the geological history of Russia.

One of the first objects is to trace accurately the outcrop of the limestone from Nicolskoy on the Tosna, eastward behind Schlüsselburg to Poutyelova, the nearest known point in that direction. In so doing, the rivers Mga, Moïka, &c. will be the places most likely to exhibit natural sections, and their banks, I doubt not, will be found equally interesting, if not equally beautiful, with those of the Ishora and Tosna. Of course, if such researches can be prolonged beyond Poutyelova and the Sas, much information cannot fail to be collected. The southern outline of the limestone along the vale of Novgorod; its prolongation westward through a part of the *goot* of Pscov, and the north of Livonia and Esthonia will also afford ample space for the labours of a geological investigator. It will also be useful to follow the northern escarpment from the vale of Ropsha by Gastilitzi and Caporié towards the falls of Narva; in doing which, an opportunity will offer of proving whether outliers of limestone exist or not at Soikina, or in the cape between the Luga and Narova. Every point of resemblance of it with the formations of other parts of Russia will of course be valuable: and in Esthonia, it is probable that the coast near Reval, from its indented shores and isles, and the marked character of its organic remains, will be ground amply calculated to repay the trouble of examination. This should include an excursion to the Islands of Œsel and Dago.

Each of the secondary districts of Sweden, would, if compared with that described in this memoir, present interesting features of similarity[*] to it, and be peculiarly useful in affording points of contact with the primitive rocks, to which the northern districts add the important circumstance of being overlaid by *pseudo-volcanic* beds. Though this is wanting in Scania, yet that province would perhaps be the most useful in its results, as it shews the connexions of a greater variety of rocks; gneiss, white entrochal limestone, coal and sandstone, chalk and flint, &c. and several remarkable fossils. It would perhaps give a compendium of the strata of north and central Russia, at the same time shewing their relation both to the primitive and to some of the most important of the secondary rocks, and also allowing something like proof to be made of their connexions with those of the opposite coasts of Denmark, and through their means with those of the western parts of Europe.

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[*] An examination of the national cabinet of the Mint at Stockholm, and that of the University of Abo, Hermelin's maps, Thomson's travels, and the cursory view of the country which I have been able to make myself, enable me to make these assertions without hesitation.

XXV.—*A Sketch of the Geology of the Island of Antigua,*[*]

By NICHOLAS NUGENT, M.D.

HON. MEMBER OF THE GEOLOGICAL SOCIETY.

[Read Nov. 5, 1819.]

"It were to be wished," says Humboldt, "that the Tour of the West Indies, from the coast of Paria to Cape Florida, were made by a good mineralogist, who would examine this ancient chain of mountains, broken by the action of currents, earthquakes, and volcanoes."[†]

A good description of this extensive Archipelago would doubtless be extremely interesting, not so much from any variety of simple minerals which the islands may be supposed to contain, as from the curious geological features which they present. A minute investigation, however, from the extensive field of enquiry, and from the nature of the climate and physical obstacles, can hardly be expected from one individual, and must probably be effected by the joint exertions of persons in different islands.

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[*] In the sectional views (Plate 34) which accompany this paper, I have to acknowledge the assistance of my friend the Rev. L. Stobwasser, an intelligent Missionary of the United Brethren, resident in Antigua.

[†] Personal Narrative, 4th vol. p. 28.

No island of this cluster will perhaps be found more worthy of notice than Antigua; which, though it possesses none of the sublime features which frequently characterize primitive countries, and is entirely free from the modern vestiges of volcanic fire, does yet exhibit, in a singular degree, both in its outline and in its component rocks, the awful havock which has attended former revolutions of the earth's surface.

Antigua, situated in 17° of north lat. and in 62° of west long. contains 108 square miles, and about 69,000 acres.

The most superficial beds occupy the northern and eastern parts of the island, and belong to a peculiar calcareous formation, more recent than those to which the attention of naturalists has been principally directed, and probably contemporaneous with that which has latterly been described as occupying the districts in the neighbourhood of Paris, the Isle of Wight, and other places, and which future observation will probably demonstrate to be very common in this quarter of the globe. The southern limit of this tract may be traced from the neighbourhood of Marble Hill Estate, by the wood, Cassada Garden, Paynter's, Sir Geo. Thomas's, Freeman's, Burke's, Willis's, Bodkin's, and Cochrane's, to the margin of Willoughby Bay, as is marked in the coloured map and sections, plates 32 and 33. The general outline of these calcareous beds, particularly in Nonsuch, is extremely broken and undulated, as it were, affording the same round backed hills and knolls of no great height, as are apparent in the chalk districts in England. At their most elevated points, which are probably St. Philip's parsonage and Lynch's, speaking from conjecture, they may be between three and four hundred feet above the level of the sea. The materials of which this formation is composed are by no means uniform in character or appearance; and it is not improbable that a close and minute investigation may hereafter shew that it may be divided into successive layers or beds, distinct in themselves, and containing each its appropriate fossil remains. I have never yet, however, been able to convince myself that such is really the case. Throughout the greater part of its extent, this calcareous formation consists of a closely impacted marl, readily broken down by the hoe or other means, and then assuming a friable and pulverulent appearance, either of a white or light yellowish colour, containing no other foreign admixture than that of certain shells and corallines, and perhaps decayed vegetable substances. Through this marl run, in a great many places, layers and irregular masses of various sizes, of a tolerably compact limestone, which generally breaks into rounded fragments, containing a considerable variety of fossil shells, nodules of calcareous spar, and small patches and druses of cellular and crystallized quartz, chalcedony, and agate. The infinite number of these fragments of limestone must have considerably embarrassed the early cultivators of the land, and in many parts, especially the windward districts, have been formed with great toil into walls of inclosure. In other places we observe strata of stone running through this marl, of a different character, consisting of a grit stone divisible into thin layers, as may be seen, for instance, cropping out on the high road near the Parham new work, and extending through Batty's Hope and Eliott's estates. Examined with a magnifying glass, it appears made up of very minute fragments of quartz, hornblende, jasper, hornstone, and green earth, held together by an argillaceous cement. It is for the most part shivery, breaking into angular pieces, but may occasionally be raised in large and compact blocks, and is then serviceable in masonry as a fire-stone. A third kind of indurated stratum, contained in this marl formation, is a smooth grained calcareous sandstone: extensive layers of this are to be met with near Gilbert's, and in the small islands on the north eastern coast, particularly Pelican and Crump Islands: it is that pale yellowish free-stone, of which so much use is made in building, and is composed entirely of siliceous particles, carbonate of lime, and a little oxyd of iron. Another indurated rock is occasionally found in this marl; a pudding stone, or breccia, consisting of an agglutination of fragments of differently coloured porphyries, with a gritty basis; this occurs near Belfast Chapel, and on the high road near Vernon's. The calcareous formation is replete with a variety of fossil shells and corallines, both in a calcareous and a siliceous state; but whether they are of different species from those now inhabiting the surrounding sea, future observation must point out: if a difference should be found, it will probably be in a few instances merely, the greater part (I mean those of marine origin) being certainly analogous to the existing species. One is often puzzled here in ascertaining species by only meeting with the casts. The calcareous fossils may be stated to be of two descriptions; those, which, being found in the indurated limestone, are either assimilated in composition with it, or of which the casts merely remain; and those, which, being found in the more marly parts, still preserve their original composition and configuration, and even in a considerable degree their pearly lustre and appropriate colour; so much is this the case, that one would almost be inclined to suppose they were derived from the sea within the memory of the present race, and were not the result of changes the earth had undergone in former ages; but all doubt must vanish when we find them closely attended by similar fossils, of which nothing but the casts are left, or completely changed into calcareous spar, or into flint and agate. Of the fossils common to the limestone, strictly speaking, we may enumerate, as most frequently presenting themselves, different species of madrepore, echinus, serpula, pecten, cardium, strombus, Cerithium, Ostrea, Trochus, Cyprea, Turritella, Venus, Lucina, &c. &c. Casts, principally siliceous, of Conus, Purpura, Voluta (Oliva) I have likewise met with; none of which appear to me to differ essentially from the varieties daily thrown ashore by the sea. In the marl, besides some of these genera, we have a singular association of three or four kinds of Helix,* (two or three of which appear in no wise different from the living species common every where in the island, Bulimus (Bulimulus of Leach), not known terrestrial or fluviatile here, with marine genera, as Murex, Arca, Nerita, Purpura, Chama, Trochus (whelk), &c. resembling the recent species of the same shells. The most common of these shells, particularly in the yellowish marls, is the oblong and turbinated snail; then the round and umbilicated shell the Bulimulus; then the triangular bivalve Triquetra (Blainville) and other marine shells.† There is a most abundant fossil body in this marl also, which is vulgarly called ground-pearl: it is a very small fragile globular pearl-like substance, somewhat tubercular on the outside, and breaking into thin scales, with a circular opening on one side, looking like the cast ovum or larva of some insect, and generally filled with earth: though brittle in the extreme when touched, the weather seems to have little or no effect on it; and it is found in prodigious quantity in the furrows of the land when newly turned up.‡ I know of no beds in which marine and terrestrial or fluviatile exuviæ separately exist, but the marl containing the two classes together is extremely common, and occupies a great proportion of the whole superficies of the calcareous formation. It is principally for the great variety and beauty of its siliceous and agatized fossils that this island is so remarkably distinguished beyond any similar tract of country yet described; and the greater proportion of them are found in the calcareous beds of which we are now treating. There occur in it, not only calcedonic and flinty casts of several bivalves and univalves, but an infinite variety of madrepores thus metamorphosed, with which the Society is now familiar, from the specimens formerly transmitted to it. Many of these agatised corallines appear to be of different kinds from those recent ones engraved in the work of Ellis. That division of the island called Belfast, particularly in the immediate vicinity of the church, contains the greatest quantity of these agatised corals; but they are likewise to be met with in other parts, though generally of inferior beauty. In many cases the siliceous particles appear to have been modified by the contact of the organic substance, and present in different parts the appearance of opal, calcedony, or quartz, and being occasionally tinged with iron, and probably bitumen, exhibit a vast variety of transparent and beautiful agates, enriched with dendritic traces resembling the mocha stone, which, properly worked by the lapidary, make very pleasing ornaments, and far excel the generality of coralline agates found in other parts of the world. I know of no bones or other traces of larger animals in this formation, nor is there here found any gypsum; but the calcedony in minute patches of a few inches in length is often cellular, and not unlike the burr-stone of the French beds.

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* One sent is of the genus Odontotrema of Dr. Leach.

† During a very cursory visit to Spanish Point, the south eastern part of the Island of Barbuda, distant about thirty-five miles to the northward of the marl formation of Antigua, and which is a particularly interesting spot, I found a yellow marl, containing, besides the same bulimus and helix, another species which I have not met with terrestrial, being less fragile and more rugose on the exterior, and having a notch-like indentation on the right lip; and these were in close contact with shells decidedly marine, Pyrula, Trochus muricatus, Cyprœa, and a large conch-like Buccinum.

‡ A substance exactly similar to this is very frequently brought to England from the West Indies, with collections of recent shells.—Ed.

Subordinate to the lowest beds of this calcareous formation, and lying on its more southern limit, we find extensive irregular masses of coarse chert, the situation and extent of which I have endeavoured to trace on the map. It breaks into sharp angular blocks, which become strewed over the plains, as may be seen at Constitution-hill and Government-ground; it is an exceedingly hard opake rock of various colours, with a glossy appearance on the outside of the broken masses, not always conchoidal, but often splintery in the fracture;* containing a prodigious quantity of casts of shells, chiefly of the genus Cerithium, the small cavities of which are filled with transparent quartz or calcedony: it is nearly impossible to find a bit of this rock without such traces of the Cerithium. In the neighbourhood of Constitution-hill, I have met with traces of only two or three other minute shells; and, as far as I can judge, they are Helices, or of a terrestrial or fluviatile nature. All these shells are more particularly seen in the rents or external surface of the stone, and are frequently in beautiful relief on the outside of a specimen. At the Church-hill in St. John's, which stands on a patch of chert, with marl enveloping it, there are beautiful casts in flint of ramose Madreporites, Conchs, Cockles, and other shells, both univalve and bivalve, but the flint at this place is always opake. The lower parts of these chert or petrosilex beds contain likewise a most astonishing quantity of petrified wood; the fragments cover the roads and plains for miles; being partly derived from this chert, and partly from a most singular class of rocks which comes next to be described. There are many traces of oxyd of iron about this petrosilex; and in some places, Bayer Otto's for instance, there is found a reddish brown earth, making not a bad pigment and water-colour, like raw Sienna. It may perhaps be doubted, on a casual inspection, whether these beds of flint belong to the calcareous formation, or to that which is subjacent, or even whether they are not more recent than all; but an examination of the church and Bayer Otto's hills, Rat Island, and a spot at Murray's, together with the fossil remains, decide the point satisfactorily to my mind, in favour of their belonging to the superior formation.

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* The fragments of this chert only want to be rounded by attrition to resemble exceedingly the Kensington gravel, and sometimes are not unlike the Egyptian and other jaspers in pattern, as well as blood-stone in which the red colour predominates.

Beneath these beds of marl and chert is found an extensive series of very peculiar stratified rocks, reaching all across the island from the ridge and Willoughby Bay, to the neighbourhood of St. John's. I have never before met with any class of rocks of this nature, and shall venture to call them the claystone conglomerate. The numerous strata of which it is composed, though evidently belonging to one family, are often so different in their individual appearance, as to render it no easy matter to convey an accurate idea of them.

The general outward character of the hills which are composed of these rocks, is a precipitous cliff on one side, and a gradual slope on the other, as may be noticed at Monk's Hill, and the neighbouring heights. Viewed in a hand specimen, this rock would for the most part be taken for a clay porphyry: but on farther enquiry, it possesses neither the habits (if one may say so) nor the geognostic relations of a porphyry; it is distinctly stratified, and the strata are different from one another; they vary extremely in colour, external character, and thickness, (from a few inches to many feet) but all dip at a considerable angle to the north-west. The more usual composition of this rock is a clayey basis, with minute crystals of felspar, and numerous spots of grünerde or chlorite baldogé, which is either of a lively green, or of an olive or brown hue. The latter mineral gives the rock a most distinguishing feature, and, being frequently diffused through it, also a remarkable green tinge, as may be seen more particularly at the fortifications at Monk's hill, and other buildings in that vicinity. The common idea is, that the colour of this stone is owing to an impregnation of copper, but it is more probably owing to manganese and iron. Some varieties of this formation have a blueish colour, and some a yellowish hue; others are quite even, and homogeneous in their composition, and some quite granular, slaty and shivery. The conglomerate character of this rock is derived from its having imbedded and incorporated with it, numerous fragments of all sizes of petrified wood, chert with coralline impressions, agate, jasper, blood-stone, amygdaloid, greenstone, clay and horn-stone, porphyry, porphyry-slate, lava, and other substances.* It is not every stratum of the family, however, which has this conglomerate character, some being quite homogeneous in their composition, having a dull earthy fracture, and some looking like a pale yellow free-stone, as at Scot's-hill. The quantity and variety of the substances included, especially of petrified wood, is most astonishing. These siliceous woods are all apparently of the tropical kinds, and those of the palm tribe are among the most common.

The conglomerate does not always retain a stratified form; it is not the case in Five Island division, and there the outline of the hills is different, partly from this cause, and partly from the predominance of the trap masses contained therein; it then assumes much the outline of a trap breccia. I have endeavoured to represent this by mixing the colours blue and green, in the colouring of this district.

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* All these are remarkably presented together in the Savannah, Gunthorpe's pasture, and other places. At Drew's hill, is a mass of wacké porphyry, with a strong vein of white sulphate of barytes. The coralline flints of these beds may be very readily distinguished from those of the marl formation. The madrepores are different; and in the latter case are more perfect and transparent, and have more of the varied character of agate.

† I have found several times, petrified, the bulbous part of the cocoa nut palm, where it emerges from the ground, and with the radicles which lace it thereto. One of the most remarkable specimens of fossil wood I met with in the pasture near Paynter's estate, the trunk of a tree about twelve feet in length and as many inches in diameter, rent crosswise asunder, but all the parts lying contiguous to one another.

I have marked on the map, in blue, nearly the whole mountain range, and stated that it represents trap rocks. The natural enquiry will be, of what nature are they, and to what formation do they belong. They may, I think, be referred most probably to the newest flœtz trap formation; and consist chiefly of wacké porphyry, wacké breccia, and a general trap breccia, the principal constituents of which are fragments of greenstone and wacké porphyry; they occur without any apparent order or regularity, and many of them constitute mountains of several hundred feet in extent. I am now convinced that all this trap series can be considered only as enormous boulder-shaped masses, subordinate to, and included in, the conglomerate; but having so great a preponderance over the matrix in quantity and size, as to give a distinct character and outline to the hills. The conglomerate matrix, however, with its peculiar feature of numerous spots of the chlorite baldogée, may be occasionally seen; and I have represented two or three places where it is most distinct. Generally speaking, the western part of the mountain range exhibits more of the conglomerate, as on both shores of Five Island Harbour;* and the eastern part, near Howard's and Sugar-Loaf Hill, scarcely has any trace of it. According to this idea, this part of the map should in strictness have been coloured green also; but as the conglomerate here shews little or no stratification, but occurs more in the form of beds, and as the constituent parts are different, I thought it would give a clearer representation as it is now laid down. The trap fragments of the conglomerate will thus be found from the extent of several hundred yards to the most minute size; being finer as you approach the marl, and then the more decidedly stratified the clay matrix becomes.

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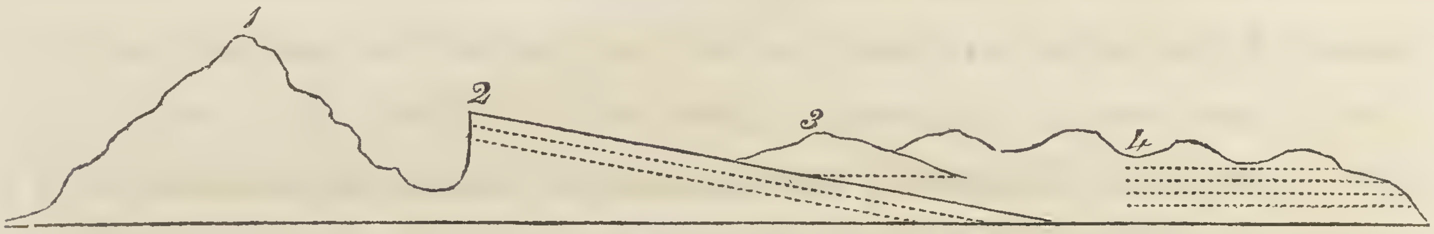
* Close to the house at the Hermitage, I perceived a few conglomerate strata in a vertical position.

The limit of the island on the south being thus composed, we cannot trace the connection between these boulder trap masses and previous formations; the only satisfaction left for the geologist is to ascertain of what rocks the surrounding islands are constituted. Without enlarging at present on this subject, I shall merely state, that the island of Barbuda, ten leagues to the northward, is entirely calcareous; and, with some singular features of its own, evidently belongs to the corresponding formation at Antigua. Montserrat, which lies about the same distance to the south-east, is volcanic: and Guadaloupe, at rather a greater distance to the south, consists of two divisions; the Basse Town, which is volcanic; and the Grande Terre, which together with Deseada, is calcareous, and like the more distant islands of Mariegalante and Barbadoes, is of contemporaneous formation with the districts which I have described in Antigua.

APPENDIX I.

The following Extracts from a Letter to Professor BUCKLAND *from* Dr. NUGENT, *in reply to some questions on the subject of the preceding paper are here subjoined, as they throw further light on the author's views of the structure of this Island.*

" LET the four formations constituting the Island of Antigua be thus designated:—Let No. 1 be the mountain trap range; 2, the stratified conglomerate; 3, beds of chert; 4, marl, or calcareous beds; and you have, I presume, the map before you. From Five Island division (say the point called Ship stern) to the entrance of Falmouth Harbour, the land is mountainous; and highest at the places marked Boggy's-hill and Biffin's, by conjecture 1400 feet above the level of the sea. It is composed of masses of trap breccia, wacké porphyry, greenstone, &c. (the latter in some places pure, but generally a ferruginous shivery greenstone) which are all imbedded or lie included, in the same, or a similar clay matrix with brownish decomposing chlorite baldogé (grünerde), as I describe to be the matrix of the succeeding beds, or many of them. No. 2; this matrix is more redundant towards Five-Island Harbour, and the trap masses bear a smaller proportion to it in that quarter than is the case near Falmouth Harbour. You will observe that this matrix in this range presents no appearance of stratification, except the partial one at the Hermitage (Fullidelph's Bay); there is no petrified wood, coralline chert, or trace of any organized substances therein; merely jasper in veins of the trap. My reason for considering No. 1 to be of same formation with No. 2 is derived chiefly from the identity of the matrix, which is most peculiar, and the masses of trap being irregular, so that they cannot be reduced to any order or succession whatever. The more I think of it, and the more I examine, the more I am convinced this mountain-range is a conglomerate (not a mere breccia) on a great scale. It is impossible to say what an original prolongation of this No. 1 beyond the present limits of the island might have afforded by detrition or debacle; but from what we now see, it cannot be supposed to have afforded all the fragments included in the stratified conglomerate No. 2. The latter contains abundantly what cannot be found in No. 1; as silicified wood, coralline chert, agate, amygdaloid, porphyry slate, bloodstone, &c. The matrix of the conglomerate strata No. 2, though for the most part similar to that of No. 1, is frequently more compact, and of an intense green colour, from the greater impregnation or diffusion of green earth; this green colour is never remarked in the matrix No. 1. I thought once that No. 3 (chert) might have belonged to No. 2, but am now confident that it is subordinate to the inferior beds of No. 4. There cannot be a doubt of No. 2 being anterior to the marl No. 4; no geological point can be clearer, than that No. 4 is the latest of all the formations here: besides, if No. 2 had been formed as an upfilling in the basin between No. 1 and 4, it would have contained some trace of calcareous rocks and substances, which is not the case, derived from one side as it derived trap fragments from the other. No. 2 likewise never contains any chert with Cerithia, which almost entirely composes No. 3. There are no quarries, sections of which would illustrate the junction, nor could any make this part of the subject clearer. No. 2 dips at a great angle, and No. 4 is not conformable but overlying.



With regard to the difference of silicified coral and wood in No. 2, and that of No. 3 and 4, I can distinguish immediately, and whenever presented to me, the corallines of the two beds, not so much from any difference in the species (though I believe them to be different) as from the state of their mineralization; their appearance is quite dissimilar; those of No. 2 are properly coralline chert, opake with small patterns; and those of No. 4 properly coralline agate, with calcedonic quartz, carnelian, &c. There is no petrified wood in No. 4; and those of No. 2 and 3 present no remarkable difference; it is difficult to distinguish the species of wood, except in the case of the palm, one of the most abundant. There are no instances of conglomerate or gravel beds lying on the marl in insulated patches, but such occur included in and subordinate to it; as at Eliot's, Vernon's, and the Belfast Chapel, mentioned in the paper. The freestone and limestone strata in the marl are not conformable to those of No. 2; but frequently horizontal, or inclined in other directions. You wish to know whether the section is correct representing the chert on the marl at Otto's and St. John's Church. I consider the chert, No. 3, to be subordinate to the marl No. 4, and occupying the lower beds of it; this does not of course preclude the possibility of a portion of the marl being under the chert; and its being so at Otto's hill, Church hill, Rat Island, and I think also Constitution hill, gave me the idea of its being subordinate to, and partly included in the marl. If subordinate, it may have marl above and beneath also; whatever marl is beneath bears no kind of proportion to the superincumbent masses, and are thin layers of a few feet thickness.

With regard to the shells in the marl, you may rest satisfied that neither the land shells, nor marine ones, which lie in close association with them, are derived from the surface; you may find them on digging forty feet into the sheer virgin marl, and at considerable elevations above the sea. The turbinated helix is the only one which is known existing here terrestrial. The lenticular shell (Bulimus?) if terrestrial, does not occur so on the island. The rugose helix with a contracted lip, from Spanish point, Barbuda, which I took out of the marl in company with marine shells, is not found recent either there or here. With regard to the singular ground pearl, I cannot be so confident, and I speak doubtingly in the paper; I believe it to be derived exclusively from the marl, though it may possibly be in some unaccountable manner the production of some recent insect on the surface, but I can get no rational conjecture concerning it; I certainly believe it to be of animal origin, and have no doubt at present that it comes from the interior of the marl, and belongs to it like the shells, but I have not that strong evidence as in the case of the latter. The ground pearl generally has an opening, as if the ovum or larva had escaped; but in a few cases I have found them without opening, containing a minute portion of mucous matter; the negroes then call them live ground pearl, but I cannot make out any reason for this. It is singular that turkies and other poultry devour these ground pearls; and their death ensues in consequence, unless immediate relief be afforded; vinegar is poured down the throat;

which probably dissolves these substances in the crop, and thus removes the distention they had occasioned. The astonishing quantity in the land puzzles me. I know of no insect sufficiently abundant to produce them in such vast quantity; the ant and the musquito are the only insects whose number bear any proportion to these little substances."

APPENDIX II.

The following notice on the Island of Barbuda is extracted from a letter to G. B. GREENOUGH, Esq. *from* Dr. NUGENT, *dated April* 28, 1818, *and is here subjoined, as connected with his description of the Island of Antigua.*

" I send herewith specimens of a compact white limestone from the Island of Barbuda. It abounds with fossil shells, belonging principally to a small species of bulla. Other shells also occur in it less abundantly, of which the following *genera* have been ascertained: viz. Arca, Cardium, Oliva, Turritella, Voluta, Strombus; also two species of Madrepore.

This island is perfectly flat, and scarcely elevated above the level of the sea, except in one corner, where it rises to the height of 117 feet. It is entirely composed of limestone, which, for the most part, is perfectly naked and bare, whilst in no place is the depth of soil greater than two or three snakes, and this is lodged generally in the clifts, or cup-like cavities, worn in the surface. There is a great deal of brush wood and copse in the island, the roots being quite superficial, or growing in the crevices of the rock. Its general aspect is that of a large flat park, to which the numerous herds of cattle, deer, sheep, horses, &c. give a farther resemblance; it may be twenty miles long and thirteen or fourteen broad.

The specimens sent are from the neighbourhood of the castle and settlement, and are probably from the most recent part of the formation. We have nothing in Antigua exactly resembling this limestone, but I saw enough to convince me that this island and Antigua belong to one general formation.

The fossils included in the rock at Barbuda appear to be in no wise different from the shells inhabiting the surrounding waters; at first one would suppose they had been thrown up by the sea, and become recently cemented together; but the rock extends many miles and may readily be connected with the calcareous formation of Antigua, in which siliceous fossils occur, and which are seen there to repose ultimately on trap rocks."

XXVI.—*Notice on the Geological Structure of a part of the Island of Madagascar, founded on a Collection transmitted to the Right Honourable the Earl Bathurst, by Governor Farquhar, in the year* 1819; *with Observations on some Specimens from the Interior of New South Wales, collected during Mr. Oxley's Expedition to the River Macquarie, in the year* 1818, *and transmitted also to Earl Bathurst.*

BY THE REV. WM. BUCKLAND, B.D. F.R.S.

MEMBER OF THE GEOLOGICAL SOCIETY, AND PROFESSOR OF MINERALOGY AND GEOLOGY IN THE UNIVERSITY OF OXFORD.

Read May 5th, 1820.

IN the present imperfect state of geological knowledge, the smallest communications from those distant parts of the globe of which the composition is altogether unknown to us, become a valuable addition to that stock of information which is gradually advancing the science of geology towards a point, at which it will be competent for us to form some well grounded theory as to the general structure of the Earth.

MADAGASCAR.

As our knowledge of the rocks which occur in the island of Madagascar is as yet very imperfect, I beg to lay before the Geological Society a few notices, which, by the favour of the noble Secretary of State for the Colonial Department, I have been enabled to extract from a series of specimens lately transmitted to his Lordship by Governor Farquhar. As these specimens were not collected by persons accustomed to inquiries of this kind, they are not accompanied by any geological memoranda, or account of the extent and position of the rocks from which they were taken; they are however valuable for the authentic information they give us of an unknown region, and as affording a useful index to future investigations.

As far as can be ascertained from these specimens, it appears that the north-east portion of the island, from which they were taken, consists of primitive rocks, sandstone, and trap, presenting a similar geological structure with that of the adjacent continent of Africa, in the neighbourhood of the Cape of Good Hope. The specimens are chiefly from Port Lougui, at the north-east angle of the island, and are as follow:

1. *Primitive Rocks.*

The bed of the river Vouluceer, which runs to this port, presents varieties of granite very similar to those which occur commonly in Europe, e. g. fine-grained grey granite, and large-grained grannite, containing flesh-coloured crystals of felspar, and resembling the blocks of Finland granite that occur near Petersburg, and from one of which is formed the famous base of the statue of the Czar Peter. Another variety of rock, nearly allied to the granitic series, is made up of equal quantities of decomposing flesh-coloured felspar and lamellar graphite. This felspar, if separated from the graphite, would afford an useful clay for pottery; there is a specimen of it from a spot called Effetou. The graphite is disseminated equally through the felspar in small flat grains resembling dark mica. A similar rock occurs on the Danube between Lintz and Passau, and supplies Vienna with graphite for black lead pencils. The remaining specimens of primitive rocks consist of a portion of soft crystallized talc, apparently from a rock of serpentine, and a fragment of slaty hornblende rock.

2. *Secondary Rocks.*

The secondary rocks are varieties of sandstone wholly destitute of organic remains, and composed of grains of bright quartz intermixed with decayed felspar of a white colour more or less strongly tinted with red oxyde of iron; some varieties of the same sandstone are compact and laminated, forming a hard sandstone slate.

These sandstones appear to be derivative from the destruction of granite rocks; and may probably form subordinate beds in a more decidedly characterized sandstone, which is said to constitute a large proportion of a hill called St. George's, in this same district.

The sandstone of St. George's Hill is of an intensely bright brick red colour, and composed of fine grains of quartz loosely adhering by a cement of red oxyde of iron, and occasionally of ferruginous clay. In some specimens it is united by shining hæmatitic iron. Brilliant grains of mica appear dispersed irregularly throughout the sandstone. Its intense redness gives it a very marked and decided character, and connects it with the enormous tracts of a similar formation which occur in the neighbourhood of the Cape of Good Hope, and which appear also to form the base of many of the great sandy deserts of Africa and Asia. It resembles in every particular of its colour and composition the newer red sandstone of the English series.

In the same hill of St. George's, there are found rocks of clay porphyry, having grains of glassy quartz disseminated through a matrix of purple felspar spotted with dirty white; this porphyry nearly resembles that which, at Newton-Glens in the county of

Antrim, and at the falls of Devon, near Kinross in Scotland, occurs associated with a similar red sandstone. In the same neighbourhood of Port Lougui, and the river Vouluceer, there are found trap rocks, which present several varieties of fine-grained greenstone, and also specimens of coarse white pipe-clay and of fuller's earth; the pipe-clay appearing to be derivative from a decomposed granite.

Besides these rocks, all of which have a strong resemblance to formations that occur in Europe, the Island of Madagascar presents a variety of that species of modern and daily accumulating limestone, which is of frequent occurrence near sea-coasts that are exposed to the action of violent seas, being composed of sand and minute fragments of ground shells, which being first accumulated on the shore, and subsequently drifted inland, are in a short time consolidated into fixed masses and compact strata.

The specimens of a rock of this formation from Madagascar, exhibit a firmly compacted cream-coloured limestone, composed of granulated fragments of shells, agglutinated by a calcareous cement, but too much broken to allow any of their species to be ascertained. Limestone of this kind is applicable to most of the ordinary uses of that mineral, and is often the only calcareous rock that occurs on volcanic islands.

There is a curious specimen of such limestone in the library of the East India House, which contains imbedded in it a small and recent bird's egg, with the shell unchanged. This specimen is from St. Helena; and bones of modern birds are said to abound in the same rock, and also to lie loosely scattered over certain parts of its surface. This is easily explained by the circumstance of the origin of the limestone, from periodical driftings by the wind of calcareous sand, over districts frequented, as these are said to be, by innumerable flocks of small birds. Such rocks are also liable to contain the exuviæ of modern land shells.

NEW SOUTH WALES.

The specimens from New South Wales were collected in the interior, i. e. on the west side of the Blue Mountains; and as their localities are not specified, it can only be stated of them generally that they afford indications principally of primitive rocks and trap. The former present several varieties of granite, with some specimens of mica-slate, clay-slate, and serpentine. Of the trap rocks there are many kinds, and a considerable variety of coarse jaspers of different colours, with some imperfect agates apparently derivative from the trap. There is one specimen of dark grey limestone which resembles the transition lime of the English series. I have seen other specimens of this kind of limestone in a similar collection made on the same expedition, and transmitted to Mrs. Hare of Shrivenham, some of which afford varieties of compact marble, others are coarsely crystalline and slaty; there are also a few varieties of quartzose sandstone interspersed with specks of decomposed felspar.

There is nothing in any of the specimens indicative of valuable metals or precious stones, or any kind of animal or vegetable remains; to the collecting of which latter it is of the highest importance that the attention of travellers in all distant countries should be directed, and more especially in this, where the character of many of its present animal inhabitants is so singularly peculiar.

It may be observed of these rocks, that they bear a general resemblance to those which have been just described from the island of Madagascar. Both series announce the presence of primitive and trap rocks, and of sandstones which appear to have been immediately derivative from the primitive rocks; whilst neither of them contain any remains of animals or vegetables. It appears, however, from specimens imported by Mr. Brown, that there is a strong analogy between the coal formation of the Hunter's River and River Hawkesbury in New South Wales, and that of England, which well deserves to be accurately investigated. That illustrious botanist, during his late scientific voyage with Capt. Flinders, collected specimens from Kingston in the district of Newcastle, on the Hunter's River, of the shale that accompanies this coal, which like the English coal shale, is loaded with impressions of the leaves of ferns. From the south side of the Table Mountain, near Hobart's town, Van Diemen's Land, he has also brought home specimens of stratified chert rock, not unlike that which accompanies the mountain limestone of Derbyshire, full of beautifully preserved shells and casts of terebratulites, flustra, milleporæ, and other organic remains, which are nearly if not quite identical with those of the mountain limestone of England and Ireland; among them is a spirifer, with its hinge distinctly preserved in delicate calcedony.

It is satisfactory to find, on comparing rocks from such remote parts of the southern hemisphere with those of Europe, that none of them afford any varieties that may not be referred to species that occur also on this side of the equator, and that as far as they go, they lead us towards a conclusion, that there is not only an identity in the older formations of rocks that constitute the earth's surface, but also a strong resemblance in the leading features of many of the secondary strata that follow and repose upon them.

XXVII.—*Supplementary Observations to Dr. Berger's Account of the Isle of Man.*

By J. S. HENSLOW, Esq.

MEMBER OF THE GEOLOGICAL SOCIETY.

[Read April 7, 1820.]

IN laying before the Society the following remarks, I beg leave to state that my intention is not to attempt a minute description of the geological features of the Isle of Man, but chiefly to point out the localities of several formations unnoticed by Dr. Berger in his account of the Island, inserted in the second volume of the Transactions. With this view I shall not trespass on the time of the Society, by repeating the description of any place he may have already mentioned, unless where I have thought him too brief or erroneous; but, as I have sometimes found it necessary to differ from him, I must offer in my defence the information I have received from gentlemen of this Society, who have assured me, that his account was drawn up from loose memoranda, long after he had left the Island, when, probably many facts had escaped his memory. At the same time, having his observations before me, I was naturally induced to become more anxious in my research wherever I imagined there appeared to be any inaccuracy in his descriptions.

The knowledge of the few additional facts that I now offer may tend to promote further enquiry into the structure of this Island; but much yet remains to be done before a complete account can be expected.

Dr. Berger himself admits his map to be faulty, and I was entirely destitute of the means of accurately correcting it; but some of the positions are so erroneously laid down as materially to affect what I have to communicate, and I therefore submit to the Society a rough sketch of the mountains (Plate 35), particularly of the central chain, which will, I hope, serve to convey at least a general idea of their disposition. The chief error in Dr. Berger's map is in the delineation of the southern group, the whole of which has been brought three or four miles too much to the east; by which means the road from Castletown to St. John's is thrown on the west, instead of the opposite side of South Barrule. Cronknyirrea-Lhaa also, as well as the mountainous ground stretching from it to Brada head, is made to rise about midway between the east and west coasts, instead of forming an overhanging cliff to the latter.

A central chain may be distinctly traced from north Barrule to Cronknyirrea-Lhaa, bearing north-east and south-west, a direction nearly parallel to the greatest length of the island. This chain includes most of the highest mountains, the tops of which are nearly in the same straight line, with the exception of Cronknyirrea-Lhaa, which lying rather to the north of this direction, gives the southern extremity a slight curvature towards the west.

As cursory observations require no particular method of arrangement, I shall follow that adopted by Dr. Berger, beginning with granite and gneiss.

Granite exists in much greater quantity in the Isle of Man, than appears to have been suspected by Dr. Berger, and may be traced further than he supposed it to extend, even where he mentions having found it. This was near the Dun, or as the Manks pronounce it, the Dtooden, a small harbour about three miles to the north of Laxey. A stream discharges itself here, and at a short distance from its mouth receives two feeders from the north, the most easterly of which is again subdivided into two courses, and it was in the southern branch of this that Dr. Berger perceived the decomposed portion of the granite he mentions. The different courses descend from a boggy land on the hill to the west, and run across the high road, but the main stream on the south is the only one of sufficient magnitude to require a bridge. Both branches of the northern feeder run over the granite as far down as their union, where it disappears. The southern branch, at one spot, runs through a vaulted excavation in its course below the road, where the rock is so soft as to admit of its being dug by the spade. If a westerly course be pursued up the hill from this spot, many places will be found where the bare rock is exposed for several yards square, and more particularly on some eminences near the top, where the soil has been washed away, and which are situate above the bog before alluded to, near the source of a stream which crosses the road about half a mile to the north, at Ballallen. It may also be traced towards the east, up the How, and though no good section is afforded in this direction, yet the disposition of numerous large blocks, unmixed with those of any other rock, sufficiently point out its extent.

This granite passes into gneiss, which is also in a state of decomposition in the excavation above mentioned, though the small portion denuded precludes the possibility of ascertaining its connexion with the granite, and confines the description to a bare exposition of the fact of its existence.

Dr. Berger mentions the composition of this granite only at the spot where it occurs in a decomposed state; but at greater elevations it is perfectly compact, the quartz and mica bearing as large a proportion to the felspar as usual. The mica is black and the varieties of texture numerous, but it is impossible to trace with any degree of certainty the beds which constitute the different changes, as no very extensive section is formed in the rock. All that can be stated is, that the greater the elevation, the more compact and less decomposed the aspect; and on approaching the stratified rocks to the south, the mica gradually yields to chlorite, the quartz at the same time becoming less abundant, till some varieties are little else than felspar and chlorite.

If I have been prolix in my directions for detecting the locality of the granite here, it has arisen from the desire of leading future geologists to the spot without that loss of time which might otherwise attend their search. For it is situate between two streams not half a mile distant from each other, whose courses any inquirer would naturally be led to explore. On finding the dip and direction of the stratified rocks which form the bed of each to be the same, he would most probably conclude that they were parts of a continuous bed, and thus overlook the granite which occupies the intermediate space: a circumstance, which not only happened to myself upon first visiting the spot, but even, as I was informed, to a celebrated geologist, who was there the previous year.

The above is the only spot where Dr. Berger mentions having met with granite *in situ*; but another more extensive tract of this nature occurs to the south of Foxdale. The main body forms a hill or ridge, stretching nearly north and south for about one mile, and is called by the inhabitants "Slieu-ny-clough," or "the Stony Mountain." The best section of this is formed by the course of the river which runs through Foxdale, and there are also several places on its summit which are laid bare in a manner similar to those mentioned near the Dun. The stream affording this section rises on the eastern side of south Barrule, crosses the road between Castletown and St. John's near the sixth mile-stone, and after flowing through a small extent of boggy land, suddenly turns down the slope on the side of Slieu-ny-clough in a northerly direction. Another section is formed by a stream running on the same side, but down the opposite slope of the hill, and here the granite is soon lost beneath mica-slate, but towards Kirk Marown it once more appears at an elevation not so great as before.

The aspect of the granite forming Slieu-ny-clough is very different from that found near the Dun; the materials of which it is composed are in general large grained, especially towards the summit of the hill. On comparison with various granites in the collection of G. B. Greenough, Esq. it appears closely allied to that from Dalky, in Ireland, and also to some towards the southern extremity of Scotland, and it is worthy of remark, that these three localities are situate in nearly the same straight line.

On Slieu-ny-clough itself, I did not perceive any gneiss, but between this and Kirk Marown church, it occurs in a few places; at a hill about midway, behind the Garth, and close to the church. At these places it rises through the clay-slate presenting a bare rock in the midst of verdure. The felspar often greatly predominates; it then has a compact texture with a few spots of mica and quartz dispersed through it; the fracture conchoidal; the structure thick slaty. A similar gneiss is met with on Slieu-ny-carnaane. No section is formed in it, but it appears to lie in a bed penetrating the mountain in a direction about north-east by east. Broken masses occur disposed in an elevated ridge, and which, from the direction of quartz veins traversing several contiguous blocks, may be known to be still *in situ.* It will readily be conceived that the granite found in working the Foxdale mines, mentioned by Dr. Berger, page 36, was a continuation of that forming Slieu-ny-Clough, since the southernmost shaft is within gun-shot of the spot where we first meet with it denuded on ascending the course of the river.

QUARTZOSE DISTRICT.

By this title I wish to designate three localities, throughout which the prevailing ingredient of the rocks is quartz, and as I know not under what head to class them, I prefer giving a description of their appearance to hazarding a conjecture. No good section is afforded which might enable us to compare their connexion with the other formations, some quarries however occur at intervals which give us an opportunity of examining their structure, which in several places consists of quartz only, very crystalline and finely granular, and would deserve the name of quartz rock, were it not associated with other varieties. The first district to be mentioned lies between the Dun granite and Slieu-Roy, on which latter mountain many large blocks are scattered, which lie bleached on the surface, and at a distance present the appearance so commonly exhibited in granite regions. A section on the west of the mountain shews this rock intimately associated with the clay-slate in broad contorted beds, the composition here consisting of the same ingredients as granite in a very comminuted state; but the general character of the scattered blocks is that of a genuine quartz rock.

To the south-east of South Barrule and Cronk-ny-irrea Lhaa, the quartz is blended with mica and specks of clay-slate, sometimes with the latter only, presenting an intermediate passage between mica-slate and clay-slate. On Slieu-ny-Carnaane the appearance is similar, and as Dr. Berger notices the occurrence of blocks of mica-slate on this mountain, he probably considered the rock of which it is composed to be of that nature.

MICA-SLATE.

Two distinct varieties of this are met with on Slieu-ny-Clough. The first occurs in laminæ about an inch in thickness, where the Foxdale river bends to the north after leaving the Castle-town road. The surfaces are richly coated with mica, giving the specimen a brilliant appearance when detached from the bed. It is traversed by veins of quartz and schorl, sometimes crystallized in alternate bands.

The other variety is met with in two or three detached places lower down the stream. The rock has a greyish aspect, and consists of fine grains of quartz and mica intimately mixed with small crystals of schorl. Layers, one or two inches thick, of granular quartz, sometimes lie between contiguous laminæ, and inclose small reddish-brown garnets. Other layers have larger crystals embedded of a liver-brown colour. Although the bed of the river is sunk through this to the depth of ten or twelve feet, and we can trace both it and the granite along different portions of its bottom, the actual contact is no where visible, but is concealed by broken masses and rubbish.

CLAY-SLATE.

Dr. Berger divides this into clay-slate and greywacke-slate, and the latter does in fact appear to exist, though the gradation between it and the former is so insensible that it is impossible to draw the line of separation, and I have preferred designating the whole tract occupied by these under the name of clay-slate, the general character being that of the Cornish killas.

The gneiss near the Dun, passes into a chlorite slate very regularly stratified. The strata run north-east and south-west, dipping at a considerable angle to the south-east. A bed occurs here about twelve or fourteen feet wide, which lies between well defined strata, but is itself in a state of confusion. It appears to have once consisted of strata similar to those which enclose it, but which from some disturbing cause have been broken and bent in every direction at the time of their consolidation. A sketch (fig. 5, Plate 35.) of a portion of this ten feet in length, representing a vertical section formed by the stream at the Dun, will convey some idea of their disposition. It is much decomposed on the surface, having assumed a brown tinge to the depth of about one foot into the rock. A vein partly composed of clay, and partly of a steatitic substance united with a considerable portion of lime and a few specks of galena, traverses this. The bed may be traced from the road side a little beyond the bridge and along the course of the stream, about half way between the former spot and the sea, until it is lost there. Owing to the inclined position of the strata, connected with the rapid descent from the top of the hill to the sea shore, the real disposition of the bed has not a direction so nearly east and west, as the section formed at the surface might appear to indicate. It is from this bed lying conformably to the direction and dip of the laminæ of clay-slate, that I presume the strata and fissile texture are in this spot coincident. The clay-slate on the western coast, between the northern termination of the red sandstone and Kirk Michael, does not assume that regularly slaty appearance which it presents on the opposite side of the island. There occur also in several places nodules of quartz sparingly dispersed, and near Balla Neah, I observed the cliffs to consist of angular fragments of clay-slate embedded in a clay-slate paste, and what is curious, these fragments are scarcely to be distinguished from the base excepting on the surface of the rock which has been exposed to the action of the waves, where they become sufficiently apparent by the fragments assuming different tinges of colour, giving the specimen a mottled appearance. One or two beds of magnesian limestone and iron pyrites occur here.

GREYWACKE.

Beds of greywackè occur in the clay-slate which do not lie conformably with the direction of the laminæ of the latter. The description of one will serve to convey a general idea of the others. On the north part of Douglass-bay at the top of the hill over which the road passes upon quitting the shore, is a quarry in which one of these occur. Two sections at right angles to each other afford a convenient opportunity of examining its position.

Fig. 1. Plate 35, is a section perpendicular to the direction of the strata, and fig. 2, parallel to them. The direction of the bed is nearly north and south (that of the strata being north-east and south-west,) and its dip is to the west. In one part it is seen traversing the clay-slate with great regularity, but in the other it becomes confused, and the schist passes insensibly into it.

On Peel hill there occur beds of a similar description; also between Port-le-Murray and the small patch of limestone to its south, and in the floor of a quarry at Port Eshee, may be seen a bed of a similar quality, and two others which apparently spring from it, intersect the slate in the manner represented by fig. 3. One of these is bounded by soft clay on one side and indurated on the other, whilst the other has the hard clay on one side, but on the opposite is in contact with the slate itself. These last mentioned beds separate into concretions bounded by remarkably plain surfaces, differing from each other in form, but which do not strictly resemble any geometrical figure. Indeed all these beds appear to possess the same property to a certain degree.

DYKES IN THE KILLAS.

Dykes, which may be termed Elvan, occur in the island. One, two feet broad, is seen near the Dun, rising through the chlorite slate, a short distance below the junction of the two streams where, it was stated, the granite becomes concealed. It is very variable in its composition, sometimes entirely quartz and chlorite.

On ascending Slieu-ny-Clough from Foxdale, along the bed of the river, there occurs a streak of granite, about one foot and a half wide, in the mica-slate which forms the west bank. No trace of it is seen on the east, but it agrees in character with a bump of granite to which it can be traced in the middle of the stream. It appears to affect the fracture of the greywackè bed above mentioned at Port Eshee. This consists of grains so exceedingly comminuted that we should scarcely be led to suspect its real nature from hand specimens.

LIMESTONE.

Dr. Berger has extended the limestone in his map too far to the north; the boundary lies in a direct line from Cass-ny-Hawin to Balla Salla. That which occurs at Port-le-Murray is also separated from the principal bed by an intervening patch of clay-slate.

In the immediate vicinity of the hill to the south of Athol bridge, the limestone encloses nodules of quartz, mentioned by Dr. Berger, p. 44. This may be traced thence, forming a broad band between Balla Hut and Balla Salla, and the appearances it presents lead me to reject his hypothesis, "that the existence of these concretions may be best accounted for by way of crystallization." I can conceive no possible objection to their being considered embedded pebbles from the shores of the sea, any more than the marine exuviæ, so prevalent throughout the limestone, to have been derived from the depths of it; but, if we examine the facts presented, I think but little doubt can be entertained of their being the worn fragments of older rocks.

In the first place, with the smaller nodules are mixed several pebbles, of large dimensions, whose structure is by no means crystalline, but granular; these again are associated with angular masses of quartz traversed by cotemporaneous veins of the same substance. The embedded materials when entering largely into the composition of any stratum appear pretty equally diffused, but when their number is comparatively small they occupy the lower portion, as if they had subsided from their greater specific gravity through matter in a liquid state.

A similar aggregation takes place in the lowest stratum of the small patch of limestone which sets on to the south of Port-le-Murray, and if I recollect rightly at Cass-ny-Hawin also.

Dr. Berger does not notice a change which sometimes takes place in the limestone, where its colour becomes reddish-brown and the texture crystalline. This appearance is slightly visible in Castletown bay, but occurs very plentifully to the south of Poolvash. Whether it forms a separate bed, in the latter case, or is merely a modification of the regularly stratified limestone is not so apparent. At one spot however, (marked *c*, *c*, in fig. 6, plate 35,) near the black marble quarries at Poolvash, two or three eminences occur of this nature rising through the regular strata, which are wrapped round and abut against them in a very perspicuous manner, the change being extremely sudden; the unstratified portion having a rugged appearance and being filled with fossils, the surrounding strata thin, slaty, and scarcely containing a trace of any.

For the characters of the annexed list of fossils I am indebted to Mr. Sowerby, who kindly undertook their examination.

1. Anomites punctatus. Martin. Tab. 37. fig. 6.
2. Producti. Min. Con. 59.
3. Productus Scoticus. Min. Con. 59. fig. 32.
4. Productus, finely striated.
5. Productus, another variety with intermediate striæ.
6. Cardium, new? See Min. Con. 82.
7. Spirifer. Min. Con. 265. Lin. Trans. Vol. 12. p. 516.
8. Spirifer, flatish.
9. Trilobite.
10. Nautilus complanatus. Min. Con. 261.
11. Ammonites Henslowi. Min. Con. 262.
12. Pentacrinites.
13. Madreporites. One of these very large and entirely new.
14. Tubipore.
15. Entrochi.
16. Caryophyllea. Several Species.

A dark shale, containing much mica, alternates two or three times with the limestone between Derbyhaven and Cass-ny-Hawin.

SANDSTONES AND BRECCIAS.

The sandstones pointed out by Dr. Berger, differ very considerably in character.

The sandstone at Peel, which alone is stratified, occurs both fine grained and under the form of a breccia; spangles of mica are dispersed through it, and it is sometimes mixed with much argillaceous matter. Strata of these appearances alternate. Towards the northern extremity of this formation, near Knocksharry, it terminates in an unstratified breccia containing limestone, agate, and ferriferous carbonate of lime. The limestone is of a dusky hue, very compact, and often an abundant ingredient. The agates are sometimes of a large size and very beautiful texture, but in general so full of flaws as to render them useless to the lapidary. Though they may be picked out from the sandstone, their union with this appears once to have been more intimate than at present, from a circumstance which happens with respect to the thin veins of crystallized carbonate of lime which traverse the bed in every direction: these invariably pass through every substance which they meet with in their course, even the smallest agates; from whence it would seem that the narrow fissures, into which this infiltration has taken place, were caused by the shrinking of the mass, during its consolidation, at a period when the texture of the different ingredients was more homogeneous than at present. If a crack of this nature were to take place now, it would most assuredly be turned from its regular course upon meeting with those agates, pass round them, detaching one side from the matrix, rather than traverse them in the manner described.

This bed is here seen penetrating and mixing with the clay-slate. Dr. Berger has committed a great mistake in supposing the whole isthmus of Langness to be composed of red sandstone. This is confined to the beach, and a small space inland, down the western side; the remainder of the isthmus being composed of clay-slate. The appearance also is totally different from that at Peel, and is that of an exceedingly rude conglomerate of quartz, slate, &c. in masses one or two feet in diameter, mixed with smaller fragments, and held together in a loose manner by a ferruginous cement. Wherever the removal of a portion of this bed, by the influence of the tide, had afforded an opportunity of examining the slate beneath, *this* appeared to have been rent and split in every direction into fragments, and these again cemented together, so that those belonging to any particular lamina may be traced for some extent, though thus confusedly disposed.

If I mean the same as that to which Dr. Berger alludes, when he says there is a sandstone overlying the limestone along the Castletown river, it is a breccia, which forms a hill immediately to the south of Athol bridge, consisting of angular fragments of quartz in a basis resembling that at Langness, but the ingredients are not so large or the texture so loose.

A breccia composed of angular fragments of limestone and quartz pebbles, loosely cemented by sand and calcareous matter, overlies the limestone at Caal Ferrane. This bed is not seen on the shore below high water mark, owing to the facility with which it becomes disintegrated by the tide.

The sand and gravel, which compose the high cliffs of diluvial detritus, towards the north of the island, are in many places agglutinated into sandstones and breccias by a calcareous cement which appears to pervade the whole of this tract to a great extent, so much so, that the roads, repaired with sand from this quarter, soon become hardened after a few showers. Fragments of shells and some nearly perfect specimens of recent cerithea, often occur sticking in the sandstone, and probably the whole of the calcareous matter here may be derived from this source.

AMYGDALOID.

From what Dr. Berger says of this formation, we might be led to suppose that the whole space between Scarlet and Poolvash was composed of a bed of amygdaloidal trap, which is not the case. The great mass of the formation is a trap-tuff of loose texture. Towards Scarlet it rises higher, becomes more compact, and acquires the character of an amygdaloid, the basis of which varies considerably in colour, assuming every intermediate shade between light grey and the deepest green. This portion appears to traverse the tuff like a broad irregular dyke, rising at intervals in abrupt masses, the highest of which, denominated the Stack, is insulated, except at low water. It is in several places split by numerous vertical fissures.

Fragments of the amygdaloid occur entangled in the tufaceous tract, as well as large nodules of the dark limestone, and even portions of its strata to a considerable extent, more particularly towards the south, where they have caused the appearance of an alternation; but I could observe no instance where the limestone might not be traced to an end, and be observed to feather out, with the evident character of an isolated mass. On examination we find that the embedded nodules, which occur so plentifully in the tuff, have been penetrated by it, and that it appears in little enclosed patches within the whole extent of their surface. Small cavities like air blebs also occur. These nodules do not appear to have lost their original colour or texture. Where the amygdaloid comes in contact with the limestone on the north, the latter for a few feet appears confused, is not stratified, contains many large cavities coated with bitter spar, and is intimately united with numerous small angular fragments of quartz, which are often exposed on the surface from the weathering of the rock.*

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* I am aware that Dr. Mac Culloch has given a different view of this tract, since this paper was presented to the Society, but having again visited the spot I am inclined to think that he has taken his ideas from supposing the portion of limestone marked (*b*) to extend further than it really does. Perhaps the impossibility of visiting this rock, which can only be approached at very low tide, may have led to the error.

I observed five dykes in this neighbourhood, three to the north and two to the south of the tuff. The composition of all these is nearly the same, consisting of a tolerably close grained basalt, the northernmost containing a great quantity of olivine. Fig. 4, Plate 31, represents the horizontal section of this dyke formed on the beach. They all intersect the stratified limestone, and one also cuts through the tuff. They do not appear to alter the nature of the limestone, except in one or two places, where it has become white and charged with a quantity of argillaceous matter, but at the immediate contact it is filled with specks of basalt and crystals of hornblende, which are entirely embedded in the manner already mentioned with respect to those portions which have been entangled in the tuff.

Explanation of the Sketch, fig. 6, Pl. 35.

a, basaltic dykes.

b, confused mass of crystalline limestone, mixed with fragments of quartz.

c, crystalline limestone rising through the regular strata, containing many fossils.

d, the more compact portion of the trap, which is amygdaloidal and porphyritic.

A dyke, similar in character to these, occurs at Brada, running parallel to the course of the metallic vein along the coast to the north of the Head.

The strata towards the southern side of Langness are much intersected by dykes of greenstone.

A bed of greenstone, in which the hornblende is remarkably well crystallized, occurs to the south of Port-le-Murray. It may be seen on the beach, a few yards to the north of the small patch of limestone there, from whence it runs inland in a westerly direction forming a ridge eight or ten feet broad. It rests on the schist, and thin veins project from it downwards. There is a bed of trap resembling the more compact varieties of that at Scarlet, but not amygdaloidal, lying to the north of the Peel sandstone. It rises from the sea, and penetrates the schist in the form of dykes.

Hornblende slate is seen behind the Garth, near Kirk Marown, but whether in contact with the gneiss there, I was not able to determine, owing to an intervening spot of cultivated land.

SIMPLE MINERALS.

I have but little to add to Dr. Berger's list of simple minerals.

Fibrous Actinolite occurs in a decomposing state near the Dun, in two veins, each about six inches broad, traversing the decomposed portion of the granite and gneiss. It is accompanied by quartz, which it penetrates and frequently colours. It may be taken from the vein in fibrous bundles of three or four inches in length, but it is in general so much decomposed as to have assumed an earthy form. In this state it is mentioned by Dr. Berger, p. 54, under the name of Dun earth. On pressing the fibres between the fingers they crumble to a harsh powder capable of taking away the polish from glass, and consequently very unfit to be used in cleaning plate, a purpose to which it has been applied. I found a single specimen in which the fibres were flexible. Specific gravity=3,03.

I met with a worn lump of the arseniate of lead among the rubbish of the Laxey mine.

Veins of chlorite occur in different parts of the island traversing the clay-slate, and often colouring the quartz by which they are accompanied.

DILUVIAL DEPOSITES.

Curragh is a name given, in the Isle of Man, to any tract of peat bog. A large extent of land, called *the Curragh*, now under cultivation, and lying to the north of the mountainous tract, formerly consisted of this substance.

Much discussion has been excited in the island concerning the origin of its peat, some affirming that it is daily formed by the decay of certain aquatic plants, whilst others attribute its existence to the ruin of ancient forests. Those who favour the former hypothesis draw their conclusion partly from the phenomena observed upon cutting it. The method pursued is to take off the surface, which consists of vegetating matter, and having dug a trench to the depth of a few feet, to replace this on this bottom, when, in the course of time, this trench becomes filled up by a fresh body of peat, a circumstance attributed to the growth of the vegetable that is found on the surface. The opposite hypothesis accounts for the trench becoming replenished, by supposing the peat which forms its walls and base to yield to the pressure existing on all sides, and thus gradually filling up, in the manner that a ditch becomes obliterated when dug in soft mud.

It is not my intention to enter into an examination of the merits of either hypothesis, nor have my sparing observations on this head at all qualified me for such an office. Perhaps to the union of the two causes may be attributed the formation of the curraghs in the Isle of Man; but certain it is that some great catastrophe has here overwhelmed large tracts of forest land, and I am indebted to H. R. Oswald, Esq. of Douglass, for much of the information I received respecting the nature of these and the various trees which are found buried in them.

These curraghs exist both in the low lands and on the tops and sides of mountains, are very variable in their depth, and in most of them are found trees of a considerable magnitude, principally oak and fir; hazels also, with their nuts, are common, sometimes ash, walnut and black alder are met with, and in one instance holly has been found in a mountain curragh, tolerably green, but rotten and incapable of bearing exposure to the atmosphere. These trees never assume the appearance even of a partial conversion to charcoal, but the more they lose their original structure, the looser and softer they become. The oak is frequently tinged of a deep black colour, and is liable to split and crack when brought to the air, unless carefully seasoned by a gradual exposure; a large trunk will require two or three years training before it can be wrought with any degree of safety for purposes of ornament, but will then admit a polish no way inferior to ebony.

Towards the north the trees lie in general upon a bed of clay; some in the deeper curraghs are still erect; a few are torn up, but the generality are broken off about two or three feet from the roots, and are disposed parallel to each other, with their heads lying towards the north-east; any casual deviation from this position may be attributed to some obstacle, as the branches having changed the direction of their fall. The smaller boughs have either totally disappeared or lie crushed together in one mass.

This general disposition of the trees was long ago noticed by Sacheverill and Bishop Wilson, and is still fully believed to exist by the inhabitants, but I had no opportunity of examining this myself.

Between twenty and thirty years ago, during a violent storm, the sea laid bare a forest, about midway between high and low water-mark in Poolvash Bay, which had been covered with sand. It remained thus exposed for two or three days, and was seen by several people. The trees were of the pine tribe, and lay disposed in the same direction as those before mentioned, from south-west to north-east. Tradition reports a fine meadow to have been washed away hereabouts, by the encroachment of the sea at a very distant period.

In addition to these general remarks upon the curraghs, I shall mention some observations I made in the parish of Kirk Balaff, upon a substance which the farmers use there as a marl. It is confined to a spot within the compass of a few acres, and in it are found the remains of the gigantic Elk. Over this marl, to which I shall presently revert, is a bed of sand six feet thick and of a light colour; upon this lies a kind of peat, about a foot and a half thick, composed of rotten leaves, and small branches closely matted together, mixed with sprinkles of sand and containing a vast number of the exuviæ of beetles, bees and their nests, crushed together with seed-vessels, rotten, but having their external coating well preserved. This bed has not the wet and thoroughly decomposed aspect generally to be observed in peat; probably from the sand beneath absorbing the rain and moisture, and thus enabling it to remain in a state of unusual preservation. In general the hard wings are the only parts of the beetles which are preserved, and these are in appearance as fresh as on a living insect. Dr. Leach was enabled to identify a few with species at present existing in England. Upon this bed lies turf and vegetating matter to the depth of one or two feet.

The marl which lies beneath the sand is very different in appearance from the substances generally known by that name. It is white or greyish, and the fracture resembles that of a highly decomposed peat, though rather more earthy, and through it are dispersed in every direction the traces of small branches and roots, which partake of the character of the mass, and only become apparent where a light or dark line has traced their figure; in short a better idea cannot be conveyed of the appearance presented, than by conceiving a mass of peat converted to a loose, earthy, calcareous substance. When fresh dug it is moist, and possesses a peculiar odour, somewhat resembling that of hydrogen, which it loses upon exposure, and though it retains its texture, does not become indurated, but is easily reduced to powder between the fingers.

Upon connecting the several appearances here presented, it seems probable that an extensive forest was formerly overwhelmed by an incursion of the sea, bringing with it a large portion of sand. This sand would be sufficient to crush and keep down the main body, but some dry branches and leaves would rise to the surface and together with the insects form a scum there, which on the subsidence of the waters would remain resting on a bed of sand.

It would appear also that a herd of Elks must have here perished, so numerous are the remains which have been discovered within a small compass; but at the same time many of their bones have disappeared, if we may judge from the few which accompany the head and horns of each animal.*

Native phosphate of iron, in an earthy and pulverulent state, is sometimes found in contact with the bones; a similar substance I have observed coating the external surface of the empty shells of the Mytilus cygneus of Linnæus, which lie scattered over the fens of Cambridgeshire, after the crows have extracted the animals.

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* Whilst I was on the island, in August, 1819, two heads with the branches and a vast number of bones were dug up in the finest preservation. An ingenious blacksmith in the neighbourhood, taking the skeleton of a horse for his model, has contrived to put together these bones with great accuracy, and form a skeleton in which the only parts wanting are the half of one hoof and the end bones of the tail. It has a most magnificent appearance, stands six feet six inches to the top of the back, and thirteen feet to the tip of the horns.

From the position in which the trees are said to lie in the curraghs, it would appear probable that some overflowing of the sea, in a direction from south-west to north-east, took place at a very distant period, but the few observations I made on certain banks of diluvium in various parts of the island do not countenance this idea. Some of these occur along the road from Peel to Douglass, and thence towards Laxey. They are generally composed of gravel and sand, and contain rolled blocks of various descriptions and sizes disposed in horizontal or wavy lines. Those about Douglass contain, principally, fragments of quartz and clay-slate, but further north we meet with a few blocks of granite, at Laxey, with very many, and between Laxey and Dun, the stone fences, which have been collected from the fields in the neighbourhood, are composed of little else. This granite is of the same appearance with that at Dun, and though dispersed so abundantly to the south of that place, I did not observe any towards the north. In an undisturbed bank of diluvial detritus at Clovenstone, I found a large block of quartz traversed by crystals of actinolite similar to those met with at Dun, and another block in a similar situation about two miles to the west of Douglass.

Blocks of granite, similar to that of Slieu-ny-Clough lie dispersed for two miles over the low plains between St. Mark's chapel and South Barrule, nor have they the least appearance of resting on their birth-place, so that no cause appears so likely to have placed them there as that which scattered those of Dun. This disposition of the granite boulders appears to indicate a current having set over the country, (at least on the eastern side of the central chain) in a direction from north-east to south-west, or contrary to that pointed out by the alleged disposition of the bog trees.

Beyond the northern extremity of the mountainous group the whole country consists of diluvial matter, raised in many places to a considerable height above the level of the sea, excepting to the north of the Balla Chirrym hills, from whence there extends, to the point of Aire over two miles, a low sandy plain covered with rolled pebbles.

Dr. Berger has remarked, p. 34, that it is by some asserted, that the sea loses ground here at the rate of two yards per annum, but from enquiries made on this point, I am inclined to think this circumstance overrated. Though all who have lived long in the neighbourhood allow that there has been a very sensible increase of land within their memory, the mean rate at the utmost would not appear to exceed half that mentioned.

The cause of this increase may possibly be ascribed to the tides which act upon the island. These enter the Irish channel at two quarters, that from the south running up the island meets the northern between Kirk Maughold and the point of Aire, where their united efforts form the flood, and their strength being exhausted by opposing forces, we may imagine that they would leave deposited whatever each brought with it, causing an extent of shallow water for a considerable distance. It will readily be seen that the body of water raised over this deposite would not, on subsiding, produce the same effect in removing as a current in accumulating it; thus permanent additions would daily take place, and the portion contiguous to high water mark become gradually covered with soil and vegetation till it is at length removed without the influence of the tide. The numerous blocks of various descriptions and magnitude found along the north coast, are probably derived from some distant spot, for although several of these have doubtless fallen from the cliffs, yet their vast number precludes the idea of all having come from thence, more especially on the north-east quarter where the sea does not wash their base but in few places, being prevented from reaching it by a slight accumulation of sand and pebbles. But the blocks which are scattered through the high cliffs of sand and gravel were themselves most probably derived from the very same source as their neighbours on the beach.

XXVIII. *Description of the Quartz Rock of the Lickey Hill in Worcestershire, and of the Strata immediately surrounding it; with considerations on the evidences of a Recent Deluge afforded by the gravel beds of Warwickshire and Oxfordshire, and the valley of the Thames from Oxford downwards to London; and an Appendix, containing analogous proofs of diluvian action. Collected from various authorities.*

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[Read December 3, 1 81

It was long ago observed by Dr. Kidd, and is mentioned by Mr. Playfair, that the Lickey Hill (Plate 36), between Birmingham and Bromsgrove, in Worcestershire, is the nearest source to which it is possible to trace the origin of the siliceous pebbles which are accumulated in immense quantities over the plains of Warwickshire and the midland counties, and which are found also on the summit of some hills in the neighbourhood of Oxford, and in the valley of the Thames from Oxford downwards to its termination below London. But as neither of these gentlemen had leisure to ascertain the extent and circumstances of this hill, and as its occurrence here is attended with many curious facts calculated to throw light on the geological history of the surrounding country, I undertook its examination with Count Breunner, of Vienna, in the summer of 1819, and beg to lay before the Society the following results, which with his assistance I was enabled to obtain.

I shall designate the ridge of hills which more peculiarly demand our attention by the name of the Lower Lickey, to distinguish it from the more elevated range of the Bromsgrove or Upper Lickey, which overhangs it on the south-west, forming the highest summit and great land-mark of the surrounding country. This Bromsgrove or Upper Lickey range stretches from north-west towards south-east, at the distance of about eight miles from the bed of the Severn, and divides the upper part of the vale of Worcester from the more elevated plains of Birmingham; having its north-west termination in the Clint and Hagley hills near Stourbridge, and being continuous thence south-eastward to Tardebig, on the east of Bromsgrove, whence it stretches by Feckenham forest to the Ridgeway on the west of Alcester, and there slopes off into the vale of the Avon above Evesham. It will be seen by reference to the annexed map, that the road from Bromsgrove to Birmingham crosses nearly at right angles through both the Upper and Lower Lickey ridges, and in the valley between them is an inn, from which their examination may be conveniently conducted.

The Upper Lickey ridge is composed chiefly of sand and loose sandstone, belonging to the new red sandstone, or red rock marl formation; and some of its strata are extensively charged with pebbles that agree in substance with the quartz rock of the Lower Lickey, and are mixed with other pebbles of common white quartz, black and variegated jasper, flinty and chloritic slate, many varieties of porphyry, and of grey and variegated compact and granular sandstone. Similar pebbles are also accumulated in vast abundance on the surface of these sandy strata, forming thereon irregular and unstratified masses of diluvian gravel, which being in some cases derivative from, and similar in substance to, the regular beds immediately subjacent, it is not always easy to distinguish those portions of the latter, which are highly loaded with pebbles, from the diluvian gravel. In this gravel there occur also large boulders of chert, with casts of entrochi, and large blocks of various kinds of porphyry, which latter are most abundant towards the bottom of the hill near Bromsgrove.

The Upper Lickey range, in that part which is intersected by the turnpike road, is composed wholly of new red sandstone and superficial gravel; in other parts it contains also strata belonging to the old red sandstone formation, and affords quarries of the calcareous breccia called cornstone, in several places further westward, along the slope and base of its east frontier. The line of this frontier appears to have been the scene of great disturbances at a period antecedent to the deposition of the new red sandstone.*

Subjacent to this ridge is that of the Lower Lickey, and the most advantageous position for seeing its connection with the surrounding country is the crest of the Upper Lickey, which overhangs it with an escarpment facing nearly the north-east. Its appearance from hence at once marks it to be composed of materials wholly different from any other rock in the neighbourhood. A narrow ridge of camel-back'd hills rises suddenly in the plain beneath us, presenting on a small scale the wavy and pointed outline of a chain of primitive or transition formations, and extending in a straight line about two miles from north to south, whilst the greatest breadth of its base scarcely exceeds a quarter of a mile; it is intersected from the summit to its base by four transverse vallies, which contribute to give the camel-back'd appearance to the intermediate eminences, and on the side of the high road which passes through a winding defile formed by the most easterly of these vallies, are quarries that afford the best and almost only sections in the whole ridge.

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* Quarries of corn-stone are wrought to obtain lime for agriculture at four or five spots about three miles north-west of the Lower Lickey, between the village of Frankley and the base of the Clint and Hagley hills, on the south side of the road that leads from Hagley to Hales Owen.

The surface of these hills is barren and scantily clothed with heath, through which the rock occasionally protrudes in a state of perfect nudity and sterility. Their interior is composed principally of semi-transparent quartz, having disseminated, and as it were floating throughout its substance, small crystals of red and yellowish felspar, which is usually in a state of decomposition. The quartz is stratified in beds varying from an inch to many feet in thickness; and where thickest, often losing all traces of the minor laminæ which generally pervade it. In great part of the rock, however, the planes of the strata are distinctly visible; they are separated by thin laminæ of soft argillaceous slate, highly micaceous, and of a reddish colour. Mica is rarely found disseminated with the felspar crystals through the quartz, but angular flakes and irregular lumps of decomposed yellow felspar abound wherever the slaty laminæ enlarge themselves to any degree of thickness exceeding a quarter of an inch. Similar felspar is also found in most of the larger interstices, and occasionally in minute fissures, that divide the quartzose strata in lines parallel with their planes, and split them into millions of small angular fragments of irregular form, so that it is scarcely possible to find a solid block of one foot in diameter, except in those cases where the felspar is sufficiently tenacious to hold together the quartzose fragments in a kind of breccia. Most frequently these interstices are entirely empty, and the rock, in consequence, falls immediately into small pieces on being moved from its native bed, so that without artificial fracture it is applicable at once to the purposes of small gravel. These quartzose fragments, into which the entire rock is as it were shattered, are of extreme hardness, and vary in substance from compact transparent glassy quartz to an opake coarse-grained sandstone. An intermediate state between these extremes is however most frequent, presenting on fracture a subgranular structure, the grains being usually more brilliant than the siliceous matrix in which they are set; but the gradation from this state into the two extremes is so insensible, that it seems almost impossible to consider those apparent grains of sand to be any thing more than concretions bearing the form of rounded fragments.

The dip of the strata, where it is most distinct, in the great quarry by the road side, is 30° south-west; at another opening towards the south extremity of the ridge, and near a small projecting mass of trap-rock, they are considerably contorted and bent backwards, but the sections are too few to give any correct idea of the general dip of the whole ridge.

The trap rock just mentioned in substance approaches to the nature of wacke, and occurs precisely at the base of the south-east extremity of the quartzose ridge; but it is so totally covered with soil and grass, that neither its extent nor relative position can be accurately ascertained: it is visible only in two or three small fields, in one of which there occurs also an old quarry of transition limestone, exactly similar to that of Dudley; but its relative position to the older rocks is marked by no decisive section, and its extent seems limited to the single spot just mentioned. Immediately at this point, where the limestone, trap, and quartz rock appear thus confusedly crouded together, the new red sandstone sets on, and throws an impenetrable veil over them all.

The trap is found only at the south-east extremity of the ridge of quartz, but the transition limestone appears once more towards its north extremity, at a place called Colmer's farm, and at the distance of three-quarters of a mile eastwards from the quartz; here again there is no section to guide our conjectures, and we find the space intermediate between the limestone and quartz rock occupied by an insulated patch of coal measures, whilst on the north-east side of Colmer's farm there are quarries of old red sandstone, containing subordinately calcareous beds of cornstone.

On the west side of the ridge of quartz, dividing it from the Upper Lickey, is a triangular valley containing coal measures, which, like those of Colmer's farm, have never yet been wrought on any extensive scale; but there is no section which affords any decided evidence of their dip; the valley being inclosed by the high ridge of quartz projecting suddenly on its east frontier, and the still higher escarpment of young red sandstone which overhangs it on the south-west, and being terminated southwards by the union of these two ridges at an acute angle. From this south point the new red sandstone sweeps round it at a low level, touching the east base of the Lower Lickey up to the spot where the Birmingham road emerges from the great defile, and thence retiring eastwards, so as to leave uncovered the coal and lime, and old red sandstone strata of Colmer's farm; so that the Lower Lickey, with its little group of attendant rocks, more ancient than the new red sandstone, is encircled on every side with an investiture of beds of the latter formation, abutting against and overlying, horizontally, the basset edges and inclined strata of the former. Beyond the north extremity of the Lower Lickey to the base of the Clint and Hagley hills, the country is composed of a fundamental rock of old red sandstone, having the new red sandstone ierrgularly and unconformably strewed over it; but, from the similarity of colour and substance in the beds composing these two formations, it is impossible to trace accurately the precise limits of each, the only sections being at a few quarries where the cornstone is extracted from the old red sandstone, to be burnt to lime.*

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* I have thought it expedient to apply the local term cornstone to a kind of breccia, known generally by that name in Herefordshire, where it is found perhaps more abundantly than in any other English county. It occurs in the form of subordinate strata in the old red sandstone, and its dip is always conformable to that of the marl or sandstone beds between which it lies. It is composed of marl and marlstone, filled with concretions of compact limestone, presenting the fracture and colour of mountain limestone, and varying in size from that of a pea to blocks of many tons, and sometimes spreading itself out into thick and compact beds, to the almost total exclusion of the marl. The knotted characters which these concretions assume resembles that of a conglomerate animal gland, and the small acini or kernels of which they are composed usually separate under the blow of the hammer. The transfusion of their outer portions and projecting points into the substance of the marlstone, shows them not to be fragments resulting from the destruction of any older rocks of transition limestone, but concretions of contemporaneous origin with the marlstone, in which they are imbedded. The marlstone itself also has occasionally a similar tendency to form concretions, in which the sharpness of the angles shows it to be quite impossible they could ever have been submitted to the process of rolling; and the appearance resulting from the union of the calcareous concretions with the marlstone, is that of an angular breccia, resembling in structure the vert antique, and some of the Sienna and African marbles; in which the fragments have never been submitted to the process of rolling.

From the tubercular knotted condition of these concretions, and the non-appearance in them of any traces of organic remains, we derive a character of high importance in distinguishing cornstone from a calcareous conglomerate which very nearly resembles it in the new red sandstone; the fragments in the latter case being most frequently rolled portions of transition and mountain limestone, which can be identified by their organic remains, and of which various truncated sections are presented on the circumference of the fragments. In those cases where they have been rolled only to a short distance from their native bed, the angles of these fragments have undergone a proportionally small degree of attrition. They occur sometimes loosely mixed with other pebbles and sand, and sometimes united into a firm breccia by a calcareous cement which is highly charged with magnesia, and which in the absence of the pebbles often enlarges itself into extensive beds of dolomite. This calcareous conglomerate occurs subordinately among the mixed pebble beds of the new red sandstone, and like all its other members is disposed in horizontal strata lying unconformably on the basset edges of rocks more

The quartz rock of the Lower Lickey being thus skirted on each side by a small coal-field, and having on its east frontier two minute patches of transition lime, with a little trap at its south end, and a small portion of old red sandstone containing cornstone near its north extremity, is, together with them, completely insulated and inclosed by a vast extent of new red sandstone, abutting against and covering them up on every side, and dividing them from the nearest trap, lime, and coal formations at Dudley, on the north, at Shatterford near Kidderminster on the west, and at Abberly on the south-west, between which points these small fragments, though apparently so minute, form a valuable connecting link.* On the north-west of Dudley, the chain of these formations is again resumed in the little mountain group of the Wrekin, and in Caer Caradoc, where the quartz rock occurs under circumstances that leave no doubt as to its age and relative position.

As there has been a difference of opinion on this point, as far as relates to the Lickey quartz rock, some geologists considering it of the same formation with the millstone grit of Derbyshire, others thinking it a peculiar variety of the new red sandstone formation,

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ancient than itself, so that it may sometimes rest immediately on the edge of inclined strata of cornstone.

A good section, in which it may be seen reposing on the basset edge of a siliceous conglomerate belonging to the old red sandstone, has been described by Mr. Warburton and Dr. Gilby, in the Banks of the Avon below Bristol, and on the north-west of Kidderminster; at Bircwood Lime-works near Shatterford, there is a thick bed of cornstone, dipping at 45° and lying subordinately in the old red sandstone, near which the calcareous pebble beds of Tremplay Green (being the breccia of the new red sandstone) rest immediately on the edges of strata belonging to the old red sandstone formation.

* I am informed there are the remains of some small neglected coal-works at Apsley heath, on the west of Tamworth; these probably form another link in the same broken chain of dislocated fragments and patches of coal-measures of which we have two cases before us at the Lower Lickey, and of which several examples occur on the west and north-west of Shrewsbury, near the edge of the new red sandstone.

and as there is no decisive section at the Lickey along its line of junction with any of the surrounding strata, we are fortunate in being able to supply this deficiency from the accurate and valuable observations of Mr. Aikin, on a rock which he considers absolutely identical with it at no great distance in Shropshire, where in the well known hills of the Wrekin and Caer Caradoc, the position of the quartz rock is, according to his observations (Geol. Trans. vol. i. p. 208, and Plate annexed) distinctly marked, extending along a considerable line intermediate between the soft grauwacke slate that flanks these chains on their south-east base, and the trap rocks that form their summits; their middle region or south-east slope being composed of quartz rock dipping under the grauwacke slate, and being identical with that of the Lickey in every circumstance of the most minute particulars of its character. Incumbent on the grauwacke slate along great part of this extent, is a thick mass of transition limestone, which terminates suddenly in the steep escarpment of Wenlock Edge overhanging the grauwacke slate, and facing towards the north-west;* the same limestone occurs also in a similar position on the south-east side of the Wrekin, and though it may perhaps be doubtful whether the quartz rock ought to be ranked in the class of primitive or transition formations, it is certainly more ancient than the youngest beds of the grauwacke slate, and probably referable to a place among the older members of the grauwacke formation.

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* This soft variety of grauwake slate, which is often found in the neighbourhood of transition limestone, is commonly distinguished in Herefordshire by the name of water-stone, as it decomposes readily into a soft grey clay the surface of which is very tenacious of water. Near Abberley the appellation of mudstone is given to the same slate for similar reasons, and in the Shropshire Coal-field it is known by the name of Dye-earth. In a subsequent paper on the coal-fields of Somerset and Gloucester, I shall give it the name of transition limestone shale, and enter more at large into its history and relations.

At the south-east base of May hill, near Huntley, on the road from Gloucester to Ross, a few siliceous beds, exactly resembling the quartz rock of the Lickey, alternate with strata of coarse grauwacke; and on the summit of a slaty mountain called the Stiperstones, a few miles west of Caer Caradoc and Church Stretton, there is a considerable mass of naked projecting ledges, composed of a coarse grained variety of this same quartz rock, which from the resemblance of its internal structure, has been sometimes mistaken for the millstone grit of Derbyshire. The same opinion has been entertained also with respect to the quartz rock of the Lower Lickey, and it must be admitted that it is possible to select from each of these formations individual specimens, the resemblance of which to one another is complete; but such resemblances are no proof of the identity in geological position, and I have before stated that the true place of the quartz rock we have been considering, appears to be towards the lower extremity of that series of depositions which are usually associated under the name of grauwacke formations.*

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* Pebbles resembling those derivative from the quartzose rock of the Lickey, are by no means confined to the central parts of England; they occur also in Scotland and Ireland; the Hon. Wm. Strangways has found them mixt with the diluvium and large boulders of Petersburg and Moscow. He has also found a native rock at Olonetz, on the Ladoga lake, and another in Catherineburg, from which they may have been derived. The rock at Olonetz being adjacent to the transition strata of the neighbourhood of Petersburg, is probably referable, like that of the Lickey, to the grauwacke series. I have myself found them abundant between Basle and the south extremity of the Vosges, scattered over the surface of the low hills that lie on the east of Altkirk; these are probably derived either from the neighbouring mountains of the Vosges or the Black Forest.

Considerations on the Evidences of a Recent Deluge, afforded by the Gravel Beds, and state of the Plains and Vallies of Warwickshire, and the North of Oxfordshire; and of the Valley of the Thames from Oxford downwards to London.

The extent of the quartz rock of the Lower Lickey, with its attendant fragments of other formations which I have been describing, is altogether so very inconsiderable, that I should have scarcely deemed it worthy the attention I have paid to it, had it not derived much greater importance from the wide dispersion and vast abundance of its ruins. The quantity of wreck we find dispersed over immense tracts of country, under the form of completely rounded pebbles of granular quartz rock, exactly similar in substance to that of the Lower Lickey, warrants us in assuming that there has been an extensive destruction of the masses from which these pebbles were supplied. Hence it seems certain, that before these pebbles were reduced to their present state, the quartz rock extended very far beyond the limits it now occupies, possibly so far as to be uninterruptedly connected with the beds of similar formation in the Caer Caradoc Group, in Salop; this and the Lickey Ridge being but residuary fragments of a once continuous chain, of which the intermediate portions have been broken down, and after violent attrition accumulated in the form of beds of pebbles in the lower regions of the new red sandstone formation, to the entire bulk of which they often contribute no inconsiderable proportion.*

The pebbles thus imbedded in the regular strata are less exposed to observation than where they occur in their more common and obvious state of superficial gravel, having been again torn up from their lodgement in the new red sandstone, by the last diluvian waters, and spread over the surface of the plains of the midland countries in quantities that are quite enormous, and dispersed indiscriminately without reference to the age or substance of the rock which lies beneath them. At Cannock Chace in Staffordshire, and at Coleshill on the east of Birmingham, the accumulation of these pebbles is particularly striking; nor are these places far distant from the Shropshire chain of the Wrekin and Caer Caradoc, from which it has been suggested a large proportion of them may have been primarily derived; the rocks of Charnwood Forest might also be supposed to have supplied many of the slaty and porphyritic pebbles that are found mixed with those of quartz rock, without obliging us to refer their origin to the more distant mountains of Wales.

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* A good example of these pebbles imbedded in regular strata of the young sandstone formation, may be seen three miles east of Kidderminster, on the road to Hagley, where beds of fine grained red sand alternate with others that are full of quartzose pebbles; they may be seen also in the summit of the hills which overhang the Severn on the east of Bridgenorth, and in those immediately south of Bewdly on the road to Stourport; and again in the deep section afforded by the road side immediately under the town of Nottingham. In the hill called Trempley Green, three miles north-west of Kidderminster, and at the quarries at Quatford and Alveley, between Kidderminster and Bridgenorth, are similar strata of siliceous pebbles, mixed with others that are calcareous, and forming with them a pudding-stone united by a strong calcareous cement. The limestone pebbles contain fragments of anomiæ and encrinites, and were probably derived from the transition chain of the Wrekin and Wenlock Edge, and broken down by the same disturbing forces that affected the neighbouring quartz rock, with the fragments of which they are intermixed. These calcareous fragments have been already alluded to in the notes on cornstone.

Similar masses of pebbles have been collected (See Plate 37) in enormous quantities along the plains subjacent to the great oolite escarpment on the north-east of Shipston on Stower in Warwickshire, particularly on the south of that town towards the escarpment of Long Compton Hill. The most common varieties here found are rounded fragments of compact granular quartz rock, and common white quartz, Lydian stone, gneiss, porphyry, compact felspar, trap, sandstone of several kinds, lias, chalk, and chalk flints.

Between Shipston and Moreton in the Marsh, they have been drifted into a kind of bay, formed by the horn-shaped headland of the Campden Hills, projecting like a pier-head some miles beyond the ordinary line of termination of the escarpment of the great oolite formation of the Cotswold Hills. The mouth of this bay opens directly to the north-east, from which quarter it is probable the current which brought the pebbles had its direction; for on the south-east of Shipston there are pebbles of hard red chalk, such as occurs not unfrequently in the Wolds of Yorkshire and Lincolnshire, but is never met with in the chalk of the south or south-east of England. The nearest possible point therefore to which these pebbles of red chalk can be referred, is the neighbourhood of Spilsby in Lincolnshire, whence a current flowing from the north-east would find an unobstructed passage across the plains of Leicestershire to the Bay of Shipston, and Moreton in the Marsh. With these pebbles of red chalk are others of hard and compact white chalk, such as accompanies the red chalk in the two last mentioned countries, and will be shewn in the appendix to occur also at Ridlington in Rutlandshire.

The diluvian current thus impelled into the Bay of Shipston, from the north-east, appears to have continued its course onwards beyond the head of this bay, near Moreton in the Marsh, bursting in over the lowest point of depression of the great escarpment of the oolite; and being deflected thence south-eastwards by the elevated ridge of Stow in the Wold, to have gone forward along the line of the vale of the Evenlode by Charlbury, till it joined that of the Thames at Ensham, five miles north-west of Oxford. (See Plate 37.)

This hypothesis affords the most satisfactory explanation of the origin of the great deposits of quartzose pebbles which not only cover irregularly the lower regions of the valley of the Evenlode, but are scattered abundantly over the surface of the oolite strata which rise to a considerable height, and form table-lands on both sides that valley along its whole extent. It also accounts for the accumulation of beds of similar pebbles on the west and south of Oxford, upon the insulated and almost conical summit of Wytham Hill, and the ridge of Bagley Wood, by their position exactly opposite the mouth of the vale of the Evenlode, at its confluence with that of the Thames, at the very point on which the driftings evacuated from the former valley would be thrown up.* Being thus introduced within the escarpment of the oolite, and having passed down the vale of the Evenlode, into that of the Thames near Oxford, these pebbles may have been forced onwards by the retiring diluvian waters, and mixt up with the gravelly wreck of the neighbouring hills in each successive district along the line of the Thames, from the vale of Oxford downwards to the gravel beds of London, their quantity decreasing with the distance from their source; so that in Hyde Park, and at the Kensington gravel, its quartzose pebbles, derivative by the course we have been tracing from the red sand strata of Warwickshire, occur less abundantly, though they are by no means unfrequent. They may be seen on the summit of the chalk hill immediately on the east of Henley and in the valley of Maidenhead, at Dropmore also, and in the gravel pits of Burnham between Beaconsfield and Windsor; in all these last named places the great mass of the gravel is composed of imperfectly rolled flints derived from the neighbouring chalk.

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* Near this same point, pebbles of clear rock crystals occur scattered over the surface at Ensham Heath, and are applied to the purposes of jewellery, like the Bagshot Heath diamonds, as they are commonly called, being merely similar small pebbles of the same substance.

The occurrence of quartzose pebbles in such high situations as the top of Henley hill and Cumnor hill, and again on the highest summit of Witchwood Forest, and the elevated plains that flank the vale of the Evenlode above Oxford, goes far to prove the recent origin of the vallies through which the Thames and Evenlode now flow; and compels us to refer the excavation of them (at least in certain parts) to the denuding agency of the subsiding waters of the most recent deluge that has affected the earth. It seems that the first action of these waters drifted forward the quartzose pebbles within the great escarpment of the oolite, and strewed them over the then nearly continuous planes of strata belonging to that formation; and that the present minor vallies were subsequently scooped and furrowed out by the retiring action of the same waters whose advance drove on before them the pebbles we are now considering; for it is not easy to imagine any other solution of the fact of the pebbles being heaped together on the summit of the insulated, steep, and nearly conical hill of Wytham and the elevated ridge of Bagley Wood near Oxford, or on the highest crest of the oolite ridge of Witchwood Forest, or the chalky summit of Henley hill; unless we adopt that which supposes the excavation of the vallies immediately subjacent to these hills to have taken place subsequently to the transport of the pebbles to their present situation on the highest summits. Nor is this hypothesis unsupported by the fact, that it is on the elevated plains that flank the vale of the Evenlode, no less than in the lower regions which form its present water-course, that the pebbles are scattered in an almost uninterrupted line, marking distinctly the course by which they have been propelled from Warwickshire into the valley of the Thames, descending along the back of the inclined and once continuous planes of the oolite strata that dip to the south-east, from their highest escarpment in the Cotswold hills.

There is another strong fact tending to prove the excavation of the vallies of the Evenlode and of the Thames near Oxford to have been subsequent to the transport of the Warwickshire pebbles, namely, the total absence of pebbles of oolite in the caps of Warwickshire gravel that crown the summits of Wytham Hill and Bagley Wood. Hence we may infer that the destruction of the oolite strata did not begin with the first rush of the advancing deluge, but was the effect of its subsiding waters returning to the lower levels, excavating combes and vallies on every side of the higher ridges, and covering the bottoms only of these with gravel composed of the wreck of the oolite strata immediately inclosing them, mixt up also with that which its rising waters had transported from more distant regions; and that the lower trunks of the vallies of the Thames and Evenlode, i. e. those portions of them which may be fairly attributed to the exclusive action of denudation, and which lie below the average level of the table-lands which flank their course, did not exist at the time of the first advance of the diluvian waters, which brought the pebbles in from Warwickshire, but were excavated by the denuding agency which they exerted during the period of their retreat.*

It is here important to remark, that although the valley of the Evenlode from its commencement to its termination is thus strewed over with quartzose pebbles, the parallel valley of the Windrush, which is closely adjacent to it on the west, and separated only by the lofty ridge of Stow in the Wold, affords not a single pebble that is not derivative from the oolite strata by which it is inclosed: this arises from the circumstance of its upper extremities taking their origin entirely within the high escarpment of the elevated ridge of the Cotswold and Campden Hills, whilst an interruption of the continuity, or at least a depression of this escarpment at the head of the vale of Evenlode, has permitted the diluvian current from Warwickshire there to pass on without obstruction into the area of the oolite,† and bring with it the wreck of the districts over which it had advanced. In the upper part also of the valley of the Thames, from that part where the driftings of the Evenlode Gap have fallen into it above Oxford, to the sources of its many tributary streams, no traces of this gravel are to be discovered; nor is there any depression along the line of the Cotswold Hills on the west of Stow in the Wold, by which any such current as that which entered by Moreton and the vale of the Evenlode could have gained admittance.

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* For a detailed and excellent description of the gravel beds of the plain of Oxford, I beg to refer to the preface of Dr. Kidd's Elements of Mineralogy, and to Chap. 17, of his Geological Essays.

† Although the oolite vallies which lie on the south-west of that of the Evenlode, are not strewed over like it with quartzose pebbles, they still afford equally convincing proofs of extensive and deep-cutting denudations taking their origin, not from a current rushing in over the high crest of the lofty escarpment that bounds their upper extremities, but simply from the weight and force of an immense volume of water subsiding within it

The excavations produced by the waters entering this lowest lip of the oolite escarpment near Moreton in the Marsh, have been so

from higher to lower levels along an inclined plane composed of uniform and moderately yielding materials. Any irregular projections that might have existed on such a plane would cause the waters to descend with accelerated velocity over the intermediate depressions, and to excavate that series of sweeping combes and vallies that wind with the regular flexures of a meandrous river, and present masses of land alternately advancing and retiring with all the uniformity of the salient and re-entering angles that usually mark the course of running water.

Striking examples of such vallies extending upwards far above the highest springs that take their rise in them, and forming vast diluvian furrows along the back of the inclined planes of the great oolite formation, may be seen in passing along the line of the Roman Fossway, from Bath to Stow in the Wold: this line, being parallel to that of the great escarpment of the Cotswold Hills, crosses nearly at right angles all the vallies that descend from them towards the south-east, into the main trunks of the Thames or Avon; and in no part of this line are the features of diluvian action more strongly displayed than between North Leach and Stow in the Wold. It is obvious that such vallies can in no way be attributed to the action of springs or rivers that now flow through them, since they often take their origin many miles above even the highest springs; their magnitude and depth bespeak the agency of a mass of waters infinitely more powerful than even the most violent water-spouts of modern times could produce; their form also differs entirely from the deep and precipitous ravines which are produced by mountain torrents; and if it should be contended that the bursting of a series of water-spouts would be competent to set in action such masses of water as might have been sufficient to excavate them, unless we can suppose these to have fallen universally and contemporaneously, not only over the district under consideration but over the whole earth, they will afford no solution of the phænomena of these and similar contemporaneous systems of vallies which occur on strata that are similarly circumstanced in every part of the known world.

The chalk downs of England, and the upper portions of the chalky and oolitic plains of France, are universally covered with a series of dry vallies exactly similar to those that occur on the back of the inclined planes of oolite of the Cotswold Hills; and the uniform texture and moderate degree of inclination which usually attends both these formations will explain the regularity of the diluvian vallies that have been excavated on them, more especially near their most elevated regions, and terminating escarpments.

In strata of higher antiquity, that have been more shattered and disturbed by violent convulsions (i. e. in rocks belonging to the coal formation, and also in the transition and primitive rocks,) the irregularity in texture and disposition of the strata on which the diluvian waters had to exert their force, has caused the features of the vallies that traverse them to be in a much less degree derivative from the simple action of a retiring flood of great, that the head springs of the Evenlode, taking their rise from the lias strata in the vale of Moreton beyond the termination of the oolite escarpment, flow south-eastward toward Oxford (through the same gap by which the diluvian current drifted in the siliceous pebbles,) instead of falling by the course of the Stour to Stratford on Avon, by what, without this lip, would have been the natural drainage of the vale of Moreton; and it is of importance to observe, that the Evenlode and Cherwell are the only rivers of all those which flow down the back of the inclined planes of the oolite strata into the Thames, which have not their head-springs within this escarpment of the great oolite. The sources of the Cherwell and a few of its earliest tributary streams being similarly circumstanced to those of the Evenlode, are thrown out in consequence of similar denudations cut through the oolite strata into the clay beds of the subjacent lias, even as far down as the town of Banbury and villages adjacent to it on the south.

The Warwickshire quartzose pebbles occur in the surface gravel

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waters; and indeed has rendered the form, inclination, hardness, and relative position of the masses on which they had to operate, essential elements of any accurate calculations of the quantity of effect they have produced; and though traces of diluvian action are most unequivocally visible in the features of every valley of the earth, we must not attribute the origin of them all exclusively to that action. In such cases as we have been describing, the simple force of retiring water on the surface of gently inclined and regular strata of chalk and oolite, is sufficient for the effect produced; but in other cases, more especially in mountain districts, where the greatest disturbances appear generally to have taken place, the original form in which the strata were deposited, and the subsequent concretions to which they have been submitted, the fractures, elevations, and subsidences which have effected them, and their partial destruction at early periods by the violent actions of water, (of which the evidence is contained in the various beds of conglomerate that alternate with the secondary strata and transition rocks;) all these and perhaps many other causes may have contributed to produce vallies of various age and form upon the surface of the earth, before it was submitted to that last universal and recent deluge, which has finally modified them all.

along this valley of denudation at Claydon and Cherwelton, near the sources of the Cherwell, having been drifted into this indenture or low lip of the oolite escarpment, though not in such quantities as those which entered by the vale of Moreton into that of the Evenlode, where the current was stronger in consequence of the projecting horn of the Campden Hills. The lowness of the oolite escarpment at the lip or gap above Banbury, appears still further from its having been selected as the point by which the Oxford Canal is conducted out into the sandstone plains of Warwickshire.

Miss Morland (to whose exertions in the cause of geology I am under extensive obligations,) has traced the Warwickshire quartzose pebbles mixed with chalk flints and slightly rounded oolitic gravel down the valley of the Cherwell, from Steeple Aston to Heyford, Rowsham, Kirtlington, and Kidlington, four miles on the north of Oxford; at Kidlington there occur mixed with them numerous shells of gryphites rolled to pebbles and probably drifted in from the lias beds of Warwickshire. She has also found similar quartzose pebbles at Long Hanborough, in the valley of the Evenlode, and below Oxford in the plains that flank the valley of the Thames between Dorchester and Abingdon. In the Abingdon gravel pits, and also in Bagley Wood, there are pebbles of porphyritic greenstone and greenstone slate, usually decomposed and probably derivative from the neighbourhood of Mount Sorrel in Leicestershire.

If we examine the geological structure of that large portion of England which lies south-east of the line of the great escarpment of the oolite formation, along its whole extent, from the coast of Dorset to that of Yorkshire, we shall find in it no one stratum that has the smallest resemblance to the quartzose pebbles which are accumulated near Oxford, and over the other districts which I have been describing; so that if they were not transported hither by the vallies of the Evenlode or the Cherwell, they must have come over some more elevated point of the oolite escarpment, and from some still more distant part of the red sandstone plains that traverse the centre of the island in a line bearing north-west and south-east, parallel and subjacent to this escarpment.

The probable history of these pebbles then is briefly as follows: Their native bed is the quartz rock of the Lower Lickey, Caer Caradoc and the Wrekin. From this they were broken down and rolled to pebbles, and buried in the new red sandstone, at the period of the deposition of that formation; from this lodgement they were again torn up by the waters of the last deluge, and dispersed by them over the surface of the various rocks on which they are now scattered. The exact identity of substance in the greater part of the pebbles with that of the quartz rock, to which they have been referred, affords a satisfactory corroboration of the hypothesis which has been suggested to explain their origin. They present the same glassy brilliancy of fracture, the same gradation from compact, through subgranular and granular, to sandy structure, the same small crystals of decomposing felspar disseminated throughout, and occasionally the same traces of lines of stratification, which characterise the quartz rock of the Lower Lickey and Caer Caradoc. We find with them several other varieties of pebbles, referable to the transition series, and occasionally to the coal formation; but these also accompany the quartzose pebbles in the beds of the young red sandstone, and are the wreck of rocks which suffered by the same destruction that affected the quartz; and thus we have pebbles of grauwacke, Lydian-stone, flinty-slate, porphyry, porphyry-slate, trap, and many kinds of sandstone, dispersed over the oolite strata of Oxfordshire, as well as imbedded in the pebble strata of the new red sandstone formation in the plains of the Midland counties.

Having endeavoured to establish an identity in point of substance between the quartzose pebbles of Warwickshire and Oxfordshire and the rock of the Lower Lickey, it only remains to mark one circumstance in the character of the latter rock which shews it to be particularly calculated to afford such pebbles as we have been attempting to trace up to it. This consists in the shattered condition in which the quartz occurs in its native bed; being a state calculated to afford the greatest possible quantity of pebbles at the least expense of time and friction, from the smallest bulk of rock destroyed: Whereas many rocks when broken fall into large solid blocks or tabular masses, the strata of the Lickey quartz rock are naturally cracked throughout into millions of small angular fragments of intense hardness, which barely adhere to each other, as they lie in their native beds, and fall to pieces on application of the smallest violence. A rock composed of materials so loosely set together, would be of all others the most liable to destruction by the action of currents that may at any time have been directed against it; and this circumstance may assist to explain the reason why so few portions now remain of a formation which the abundance of pebbles that have been derived from it, shews to have possessed at one time an extent by no means inconsiderable. It is almost impossible to conceive that the millions of pebbles which compose this gravel should have been derived from large blocks ground down to their present average size of a pullet's egg; and the presence of a rock in this neighbourhood which splits spontaneously into such minute fragments as have been described, supersedes the necessity of any such hypothesis. Thus we find in the Lower Lickey ridge and chain of Caer Caradoc, all the elements necessary for the solution of our problem of the origin of two distinct deposits of quartzose pebbles, the one in the new red sandstone formation, the other in diluvian gravel, they contain a mass of quartz naturally divided into minute angular fragments, and these fragments identical in substance with, and easily reducible to, the condition of the pebbles in question. The same force of water which would tear these fragments from their native beds, might, if continued long enough, reduce them to their present state of roundness by simple attrition, at a period immediately preceding the deposition of the new red sandstone. And we have the analogy of rounded fragments of the older strata of each neighbourhood in other districts throughout England, from the conglomerate beds of Devon and Somerset, Gloucester and Glamorganshire, to those of Nottingham, Yorkshire, and the Valley of Carlisle, to prove the existence of an extensive and violent destruction of the earth's surface by water at the period of the deposition of the new red sandstone; and finally, we have the mass of gravel thus buried in the new red sandstone, and remaining in it undisturbed during the period of the deposition of the succeeding secondary formations, till it was again torn up by the water of the last great deluge, and scattered not only over the surface of strata composed of the same sandstone, but over almost all strata of all ages that occur in England.

When it happens, as it often does in the central plains of England, that masses of diluvian gravel, composed principally of quartzose pebbles, lie immediately on the regular sandstone strata containing subordinate beds of the same pebbles, it is not always easy to discover to which of these deposits the pebbles ought to be referred, the occurrence of a section is usually decisive of this point, and the discovery of a single fragment of any rock more recent than the new red sandstone, is sufficient to shew the mass to be not referable to that formation; e. g. the presence of pebbles of lias and red chalk in the quartzose gravel near Shipston, shews it to be certainly of more recent origin than both these strata.

It appears certain, that the state of roundness which the quartzose pebbles have attained, has resulted from the friction they underwent before their first lodgement in the red sandstone; and if we had not decisive proof of this fact from the state in which we find them there imbedded, we should have difficulty in referring their rounded condition simply to the friction they have undergone by the act of transport from the Lickey or Caer Caradoc to the plains of Warwickshire, or even to Oxford. For it should seem the waters of the last deluge were of too short duration, or too tranquil, to produce on the fragments of rocks which were torn down and drifted by them, that greatest possible degree of roundness which is so universal in the quartzose pebbles we have been considering. Indeed instances are rare, where fragments even of soft rocks, which have undergone no further attrition than that of the last diluvian waters, have received that total and extreme degree of roundness which is found in the quartzose pebbles we are considering, and which is similar to what we now see produced by the long continued action of violently agitated water on fragments exposed to the waves on the sea shore. This fact is a strong proof of the short duration of the last deluge, and may be illustrated by the state of the angular portions of gravel on the plain of Oxford,* or in Hyde Park.

The same observations which have been made on the quartzose pebbles of the new red sandstone formation in Warwickshire, may be applied to the pebble beds of the plastic clay formation above the chalk, (the indurated varieties of which are well known as the puddingstone of Herts, their common state being that of the loose gravel beds of Blackheath). These pebbles are composed of chalk flints rolled to the same extreme degree as the quartzose pebbles of the new red sandstone formation, and having received their attrition at a period subsequent to the consolidation of the chalk, and long anterior to the last universal deluge. Both these pebble beds, formed at periods far distant from each other, have shared the common fate of all strata, in being broken up and ravaged by the waters of that deluge, and mixed with the angular gravel which was torn by them from rocks which had undergone no other previous attrition. And accordingly we find rounded pebbles derivative from the plastic clay formation mixt with the angular and imperfectly rolled chalk flints which constitute the great bulk of the London gravel; the latter having undergone no further attrition than that to which it was exposed during the short period of the last great deluge that has overwhelmed the earth.

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* See Dr. Kidd's account and reasoning on the Gravel of the plains of Oxford, in the preface to his Mineralogy.

In the gravel of the valley of Oxford we also mark the same distinction between *angular* and *completely rounded* pebbles; the fragments of the neighbouring hills being angular, and slightly rolled, and those only being completely rounded that can be traced up to ancient gravel beds, forming part of the new red sandstone strata of Warwickshire, the pebbles of which have been shewn to have received their attrition at an early period in the history of the revolutions that have affected the surface of our planet.

A difficulty occurs frequently along the base of a mountain chain, in marking the exact line which separates the deposits of post-diluvian detritus, which have been and still continue to be drifted down by wintry torrents, from that gravel which is strictly of diluvian origin. The bursting of an Alpine Lake (such as occurred in June, 1818, in the valley of the Dranse in Switzerland), and the daily action of torrents and rapid rivers in times of flood, is competent to produce partially over a limited district beds of gravel somewhat similar to those of the great diluvian waters; striking examples of this kind are afforded in the Duchy of Venice, along the base of that part of the Alps which lies immediately on the north and north-west of the town of Valvasone, where the flood waters of the Tagliamento, the Meduna, and the Zelline, have strewed the plains to an extent of many miles from the base of the mountains with a beach of pebbles of enormous breadth, which in summer is dry and barren, resembling a naked Chesil bank on the sea shore. Similar features are presented by the Torre and Malina torrents on the north-east of Udina, and by the numerous torrents that descend into the plain of Lombardy from the mountains on the north of Verona and Vicenza. The Trebbia and Taro rivers also, and all the torrents adjacent to them, which fall into the Po from the south, near Parma and Piacenza, cover the lands in the vicinity of their courses with a similar and annually increasing accumulation of detritus, from that part of the Apennines in which they take their origin. And in our own country, the small river of Avon Lwyd or Tor Vaen, which descends from the west side of the Blorenge mountain in Monmouthshire, by the valley of Pontypool, presents, at the point where it leaves the mountains immediately below that town, a naked strand of pebbles, that is perpetually shifting and laying desolate the level regions that succeed immediately to the sudden termination of the steep and precipitous mountain valley, along which the torrent has its course above Pontypool.

At the point where transverse mountain vallies fall into the great ongitudinal vallies, we sometimes find a considerable talus-shaped accumulation of post-diluvian gravel, partially filling up the diluvian gorge of the transverse valley, and protruding itself to a considerable distance into the main trunk of the longitudinal valley; many striking examples of this latter kind may be seen in ascending the passage of Mont-Cenis on its western side from Aiguebelle upwards. Here, at the termination or mouth of the transverse vallies that fall into the main valley of the Arc, immense talusses of gravel of modern origin project into the latter valley, being often incumbent on, and easily distinguishable from, subjacent beds of diluvian gravel, and sometimes protruding across the great longitudinal valley, so as entirely to obstruct it, with the exception of a small passage which is kept open by the present river, in the lowest edge of the talus. I have seen also similar examples well displayed at the mouths of the transverse vallies that fall into the main valley of the Kiszucza River on the Hungarian side of the pass of Iablunka, at the west extremity of the Carpathians. Deposits of this kind go on accumulating daily under our observation, and may, by careful investigation, be always distinguished from that gravel which is strictly diluvian, as the latter has also been shewn to be decidedly distinct from those more completely rolled pebble beds of antidiluvian origin, that occur among the regular strata which compose the crust of our globe, and which must be referred to periods of still higher antiquity, and long distant from each other, as well as from that last universal deluge which has overwhelmed the earth.

For the purpose of impressing more strongly this distinction which I have drawn between diluvian and post-diluvian gravel, it will be convenient if geologists will consent to restrict the term *diluvium* to the superficial gravel beds produced by the last universal deluge; and designate by the term *alluvium* those local accumulations that have been formed since that period by torrents and rapid rivers, and the bursting of alpine lakes, and similar minor causes which operate daily, and partially within the sphere of our own observation.

The Hon. Wm. Strangways, in a valuable Synoptic Table of the Formations near Petersburg, published by him during his late residence in that city, has adopted with great advantage this division between diluvian and post-diluvian formations; distinguishing them by the name of *diluvium* and *alluvium*. He dates the commencement of the alluvium from the period of the retreat of the last waters that have covered the earth, and includes under it—1, Drift sand marine, or inland; 2, Marsh land, composed of mud deposited by rivers; 3, Peat; 4, Calcareous tuf. All these formations are referable to causes that are still in daily action; under the term diluvium he includes the superficial gravel beds that lie indiscriminately on all strata of anti-diluvian origin, and are composed of a mixt detritus of pebbles, sand, and clay, torn down from formations of all ages, except alluvial, and also the blocks of granite and other fragments of primitive and secondary rocks, that are scattered over the plains and low hills of that part of the north of Europe, either mixt with the superficial gravel, or lying insulated in situations to which they must have been drifted from very considerable distances, as there is no matrix near them from which they could by possibility have been derived. He has omitted to mention beds of gravel produced locally by torrents and rapid rivers, because the flat condition of the district on which his synoptic table is founded, has allowed no gravel of this kind to be transported to so great a distance from the hills or mountains, from the daily detritus of which it is immediately derived.

A well digested and valuable comparative account of the mode of action and effect of rivers and mountain torrents, shewing that the *maximum* of their force is wholly incompetent either to excavate the main trunks of the vallies through which they flow, or to produce the gravel beds that cover them at a distance from the hills and mountains whence this gravel has been transported, is given in chap. 20 of Dr. Kidd's Geological Essays, and in the second Essay of Mr. Greenough's Examination of the first Principles of Geology. The same subject has been treated with equal accuracy and ability by M. Brongniart in the latter part of his "Histoire naturelle de l'Eau," published in the 14th volume of the "Dictionaire des Sciences naturelles," and separately as a small pamphlet, which I strongly recommend to the attention of those persons who wish for correct information as to the effects produced by water upon the surface of our globe.

I have now only to add a few words on the organic remains found in the beds of diluvian gravel which we have been describing. In all the gravel pits of the valley of the Thames round Oxford, at Abingdon alſo, and Dorchester and Wallingford, and Hurley Bottom near Henley, teeth and tusks, and various bones of the mammoth or northern elephant have been found abundantly. There are in the Ashmolean Museum at Oxford, some vertebræ and leg bones of an elephant of enormous size, probably sixteen feet high, and in a delicate state of preservation, which were found in the gravel near Abingdon three years ago; mixt with these occur the bones of the rhinoceros, hippopotamus, horse, ox, hog, and several species of deer, often crouded together in the same pit, and not much rolled, although they are rarely, if ever, united in entire skeletons. Fragments of sixteen horns of deer were dug up lately within a short time in the same gravel-pit, with the great elephant's bones, near Abingdon. These bones are extremely soft and tender whilst they remain wet, and harden by drying. They are not in the least degree mineralised, and retain much of their animal matter.* In the collection of the late Mr. Catcot, in the City Library at Bristol, is the tooth of a rhinoceros found in the gravel-pits of St. Clement's in Oxford, and about two years since a large grinding tooth of an elephant was found in digging gravel in one of the streets of this city, near St. John's College; in London also in digging the grand sewer on the east of Waterloo-place, near Charles-street, at the depth of thirty feet, they found not long ago a similar tooth of the same species of elephant imbedded in gravel; and in a similar matrix at Kingsland near Hoxton, in the year 1806, an entire elephant's scull was discovered, containing two tusks of enormous length as well as the grinding teeth. They have also been found frequently at Ilford, on the road from London to Harwich; and indeed in almost all the gravel-pits round London these teeth are found of all sizes, from the milk teeth to that of the largest and most perfect growth; and in all the intermediate and peculiar stages of change to which the teeth of modern elephants are subject.

In Phil. Trans. for 1813, is a report of the tusk of an elephant nine feet long, and of other remains of the same animal, with those of hippopotamus, ox, and several species of deer, and the horn of an ox four feet and half in length, all of which were found by Mr. Trimmer in the gravel of the valley of the Thames near Brentford. Six tusks of the hippopotamus lay in an area of 120 yards. In all these gravel-beds no two bones lie in immediate contact with each other, and in very few cases are they rounded by attrition.

At Newnham in Warwickshire, near Church Lawton, about two miles west of Rugby, two magnificent heads and other bones of the

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* For a further detail of the gravel beds of Oxford, Witham Hill, and Bagley Wood, and of the organic remains contained in them, I must again refer to chapter 17 of Dr. Kidd's Geological Essays.

Siberian rhinoceros, and three large tusks and teeth of elephants, with some stags horns and bones of the ox, were found in the year 1815 in a bed of diluvian gravel, connected with that which we have been speaking of near Shipston; this gravel is immediately incumbent on stratified beds of lias; it is composed of a mixture of various pebbles, sand, and clay, in the lower regions of which, where the clay predominates, the bones are found, at the depth of fifteen feet from the surface; they are not in the smallest degree mineralised. One of these heads measuring in length two feet six inches, together with one of the tusks, and a grinding-tooth of an elephant, have, by the kindness of Henry Hakewill, Esq. (of architectural celebrity) been deposited in the Radcliff Library at Oxford. The other and larger head, with a tooth and leg-bone of the same animal, has been presented by Henry Warburton, Esq. to the Geological Society of London. Of the remaining tusks of elephants, the largest is in the possession of G. Harris, Esq. of Rugby, and the other of J. Caldecot, Esq. of Lawford. These tusks have all of them a considerable curvature outwards towards the point, like those of the fossil mammoth, or extinct elephant, which abounds in the gravel of Russia, of which one specimen was found with its flesh still entire on it, bedded in a mass of ice on the north coast of Siberia, and is now placed in the Museum of the Academy at St. Petersburg, with the dried flesh and skin still adhering to its head.

In the Ashmolean Museum at Oxford there is a similar head of a rhinoceros to those found near Rugby, of the same length and proportions with them, and also resembling that engraved in vol. 2 of Cuvier's *Animaux Fossiles*, at Pl. 4, No. 12, in his chapter on Rhinoceros, and quoted by him as having been found at Lippstadt, in Westphalia, and being in the collection of Adrian Camper. It appears to have been among the original collection of bones deposited in the Ashmolean Museum, but the place where it was found is not recorded. A fragment of another head of the same species of rhinoceros, fifteen inches long, is mentioned by Dr. N. Green, in p. 254 of his catalogue of the Museum of the Royal Society, (Anno 1681) as having been found at Chartham, near Canterbury. These all belong to the same extinct species of the double-horned fossil Rhinoceros of Siberia,* and appear to have been the contemporaries and compatriots of the extinct elephant or mammoth, which is found so abundantly throughout the northern regions of Europe, Asia, and America, and even in South America in the elevated plains of Peru and Quito, buried in diluvian gravel under circumstances in all respects so similar as to oblige us to refer their origin to a common cause, viz. the latest diluvian catastrophe that has affected the surface of our globe.

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* The largest and finest head of this species of Rhinoceros which I have ever seen, has been sent to me lately from Siberia by Mr. J. Prescott, of St. Petersburg, whose kindness on this occasion has fortunately put it in my power to present, through M. Cuvier, to the Museum of the Royal Garden at Paris, a fossil which has hitherto been a desideratum in that rich and splendid cabinet. In the British Museum is a similar head, which was presented by the Emperor of Russia to the late Sir Joseph Banks.

I have lately received from Warwickshire an Os humeri and Os innominatum of Rhinoceros, in a state of preservation as perfect as if they had been dissected from a recent animal.

APPENDIX.

As connected with my present subject, I beg to subjoin a few valuable notices on the superficial gravel-beds of the midland districts of Rutland, Leicester and Buckinghamshire, by the Rev. W. D. Conybeare, with further important observations of other gentlemen on similar depositions of diluvian gravel.

The gravel, accumulated in the midland counties of England, is considered by Mr. Conybeare to be a subject worthy of much more attention than it has hitherto received. These accumulations have been observed by him to extend over the plains that lie beneath the north-west escarpment of the great oolite chain, and also over the low tract between these hills and the north-west escarpment of the chalk of Bucks, Herts, and Bedfordshire; but they are more particularly abundant in the former position, where extending many fathoms in depth, they often effectually conceal the subjacent strata, and sometimes by their accervation constitute decided hills. Tracts of this description are particularly abundant in the borders of Rutland, Warwick and Leicestershire. From Houghton on the Hill near Leicester, to Braunston near Daventry, proceeding by Market Harborough and Lutterworth, the traveller passes over a continuous bed of gravel for about forty miles; near Hinckley, great depositions of gravel, probably connected with this mass, are found, and afford pebbles containing specimens of the organic remains of most of the secondary strata in England; this deposition may probably be traced continuously to that of Shipston on Stour, most of the hillocks scattered over the lias and red marl tract between Southam and Shipston being crowned with this gravel.

These accumulations of pebbles, promiscuously heaped together, are composed of the wreck of rocks of the most distant ages, which exist in their native state only in distant quarters of the island; flints from the chalk formation, accompanied by rounded masses of hard chalk and fragments of the different oolite rocks, seem however decidedly predominant in Leicestershire; and next to these in quantity, are the granular quartz rock pebbles resembling those from the Lickey, with others of white quartz (apparently derived from veins) and dark coloured hard flinty-slate. It would however be not difficult in many places, as for instance on the west of Market Harborough, and in the valley of Shipston on Stour, to form almost a complete geological series of English rocks from among these rounded fragments, which often occur in boulders of very considerable size.

The immense quantities of fragments of chalk flints scattered in this gravel at such a distance from the present limits of the chalk, is a very observable circumstance, and seems decisively to indicate that this formation must once have occupied a much wider space than it does at present. Near Syrwell, six miles north-east of Northampton, on the oolite formation, are some fields as thickly strewed over with fragments of pure white chalk, as the surface of stony arable land is usually with the substance of the subjacent rock. Even as far as Derbyshire, chalk flints are commonly found dispersed over the surface of the country.*

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* In the Phil. Trans. for 1791, an account is given of a quarry of chalk having been worked in Rutlandshire at Ridlington. The writer of it is evidently well acquainted with the character and general limits of the chalk formation throughout England; and his account is so very precise and bears so many marks of accuracy (specifying that the chalk is not soft but hard like that of Baldock, with rows of flints lying in it which are shattered and not so black as those in the south of England,) that the extent of the chalk near this quarry must be considered a subject worthy the examination of those geologists who may

The accumulations of gravel on the low grounds between the oolite and chalk ridges along the valley of Buckingham and Bedford, and skirting the lower or south-east slope of the great oolite range, are almost exclusively composed of fragments of oolite and chalk; older pebbles being there very sparingly intermixed. Examples of this may particularly be seen at Wittlebury Forest in Northamptonshire and near Buckingham. The above observations on this subject, by Mr. Conybeare, are in perfect harmony with my own in other parts of England.

I am informed by Sir Joseph Banks, that he has observed pebbles of porphyry in the gravel used for repairing the roads on the north side of the town of Dunstable, near the escarpment of the chalk; these also are referable to the same era with those which have been traced along the vallies of the Evenlode and Thames from Warwickshire to Hyde Park, and are connected with the gravel which Mr. Conybeare has noticed in the midland districts. The occurrence of granite pebbles and other fragments of distant primitive rocks, which have been transported into the valley of the Seine, near Paris, is another fact precisely of a similar kind.

Mr. Farey, in his Agricultural Report of Derbyshire, gives a long and interesting list of the gravel patches in that county, from which it appears, that fragments of all the English formations from

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have opportunity of visiting this spot, where its limits have never been ascertained, and its distance from the great mass of the same formation renders its occurrence and circumstances deserving of further investigation. Its extent is probably very small, and it seems to present an interesting and valuable relic of the great mantle of chalk, whose distant outlying fragments which we find elsewhere, added to the enormous quantities of its wreck which are dispersed over the country in the form of diluvian gravel, shew it to have been once extensively spread out beyond the limits of its present area.

granite upwards to chalk, are accumulated in the form of diluvian gravel on the surface of all the strata which constitute that midland part of England.

It is mentioned in a paper by Mr. A. Aikin, on the Gravel at Litchfield, printed in the fourth volume of the Geological Transactions, that he found near that town pebbles of granite, syenite, greenstone, schist, limestone, quartz, chalcedony and hornstone, all of which with the exceptions of the quartz have undergone considerable decomposition; amongst these the pebbles of corralline limestone are most abundant, and like those of the chert appear to have been derived from the mountain limestone of Derbyshire, and to have been accumulated at the same period with the gravel beds of Shipston on Stour, and of the valley of the Thames.

In a very able and ingenious paper by Sir James Hall, in vol. 7, of the Transactions of the Royal Society of Edinburgh, he has recorded his discovery of similar traces of the action of a diluvian current on the surface of the hills and vallies near that city. These districts are not only strewed over with the gravelly wreck of rocks that have been drifted to a great distance from their native bed by the force of violent waters; but Sir James has also observed channels and furrows, which he calls dressings, still remaining on the surface of the hard rocks over which these waters passed, driving before them blocks and fragments of every substance that lay in the line of their course, and excavating vallies of denudation analogous to those we have described in Oxfordshire.

Mr. Weaver, in his very valuable memoir on the Geology of the East of Ireland, at p. 294 of the present volume, has discussed the subject of the denudations there displayed, and the gravel produced by the retiring action of a subsiding mass of waters, with a degree of ability that like the whole of his paper bespeaks the touch of a master's hand; his observations are important to our present subject, as adducing facts in strict unison with those which we have been tracing in England. Dr. Richardson has also given important notices on the enormous effects of analogous denudations, in his excellent paper on the Basaltic Area of the North of Ireland, published in the Philosophical Transactions for the year 1808.

Mr. Greenough, in his examination of the first principles of geology, concludes his admirable summary of phœnomena derivative from diluvian action in all quarters of the earth, with the following passages, which are much too important to be omitted in this place. "The universal diffusion of alluvial sand, gravel, &c. proves that at some time or other an inundation has taken place in all countries, and the presence of similar alluvial deposits both organic and inorganic, in neighbouring or distant islands, though consisting often of substances foreign to the rocks of which the islands are respectively composed, makes it highly probable at least, that these deposits are products of the same inundation. The universal occurrence of mountains and vallies, and the symmetry which pervades their several branches and inosculations, are further proofs not only that a deluge has swept over every part of the globe, but probably the same deluge." He also shews it to be highly probable "that the order of things immediately preceding the deluge, closely resembled the present order, and was suddenly interrupted by a general flood, which swept away the quadrupeds from the continents, tore up the solid strata, and reduced the surface to a state of ruin: but this disorder was of short duration, the mutilated earth did not cease to be a planet: animals and plants similar to those which had perished, once more adorned its surface; and nature again submitted to that regular system of laws which has continued uninterrupted to the present day."

In the works of Calcott and Hutchinson,* a mass of strong evidence is adduced and well set forth in proof of the agency of diluvian currents over large portions of the surface of this island.

De Saussure has recorded a valuable series of observations on the effects of the debacle, or breaking up and transport of rocks and gravel, produced by an enormous rush of subsiding waters in Switzerland. These effects appear to be only a larger feature of that same diluvian action which we have been tracing in the central parts of England, and which in that country are on a scale proportioned to the magnitude of the Alpine masses on which it had to exert itself. For the detail of these effects, I must refer to the author's own descriptions, and also to Sir James Hall's excellent paper in the Edinburgh Transactions before alluded to, in which he offers some most ingenious conjectures as to the probable mode by which the stupendous operations which have taken place in Switzerland were brought about.

In Buffon's History of the Epochs of Nature,† we find his description of the state of the vallies of France, and of their forms as derived from the excavating force of a retiring mass of waters, to be in perfect harmony with those of the other writers whom I have been quoting, and to whose observation on their own countries, where they had opportunities of conducting the most accurate investigations, I would request all persons who feel an interest in this subject to direct their attention.

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* See Calcott on the Deluge, 1768, and Hutchinson's Works, vol. 12.

† Vol. 12. p. 159. Deux Pont Edit. 1782.

But above all I would refer them to the opinions of M. Cuvier, expressed in his inestimable Essay on the Theory of the Earth, in which, after the most enlarged and philosophical view of the state of the question that has ever been taken, he concludes with expressing his conviction, "that if there be any one fact thoroughly established by geological investigations, it is the certainty of the low antiquity of the human race and present state of the surface of the earth, and the circumstance of its having been recently overwhelmed by the waters of a transient deluge."

These united authorities present us a mass of evidence collected from the highest sources that are accessible, all conspiring to establish the important fact, that accumulations of superficial gravel more modern than the most recent of the regular strata are found in all parts of the world, under circumstances of such exact resemblance, that it is impossible not to refer them to one and the same common cause, viz. a recent deluge acting universally and at the same period over the surface of the whole globe.

XXIX.—*Observations on the Eastern Part of Yorkshire;*

By N. J. WINCH, Esq.

HONORARY MEMBER OF THE GEOLOGICAL SOCIETY.

[Read April 19, 1816.]

DURING the course of the year 1814, I had the honour to lay before the Society a paper on the geology of Northumberland and Durham.* It is now my intention to extend that sketch towards the South, taking the Humber and the great north turnpike road for the southern and western boundaries of the district to be described, and the German ocean and the river Tees for the western and northern ones.† It is here proper to remark, that the former are only ideal limits to the formations under consideration; but the latter are real terminations of the rocky strata, a brief account of which will constitute the subject of the following observations.

The length of this district is about 60 miles, and its extreme breadth 40; and though the mineral treasures it contains will bear no comparison in respect to number and value with the productions of the country situated to the north and north-west, yet extensive quarries of alum-shale, together with freestone, limestone, chalk, ironstone, and a few thin seams of coal, add in some degree, to the riches of the landed proprietors, and give to many of the poorer inhabitants the means of comfort and support.

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* This was printed in the Transactions, vol. 4.

† By referring to Mr. Greenough's Geological Map of England, most of the places mentioned in this Memoir will be found.

To begin at the northern extremity of this tract of country, it is necessary to recur to a circumstance mentioned on a former occasion,* viz. that the Tees flows over rocks of fine-grained red and white calcareous sandstones devoid of mica, from a short distance above Croft bridge to the sea.

These beds, which must not be mistaken for the old red sandstone, certainly rest upon the magnesian or Sunderland limestone, and are covered by the alum-slate; though I must acknowledge I have never had an opportunity to ascertain this important fact. This might be done by ascending the little river Leven, from Stokesley towards its source in the mountains; for near the mouth of the Tees, the places where these formations come in contact are buried below alluvial soil or extensive sand banks.

This sandstone formation, containing gypsum, skirts the hilly country on its northern and western acclivities for a considerable distance from the Tees, and may again be recognised on the banks of the Trent near Newark, where the hills are gradually lowered into level plains. The soil arising from the detritus of this sandstone partakes of the brick red colour of the rocks from which it is detached; and the fine crops produced in the vale of Cleveland prove it to be highly favourable to the growth of wheat.

Of the mineral springs rising at Dinsdale and Croft, notice has been taken on a previous occasion;† and for the analysis of the former, I must again refer to Mr. Peacock's pamphlet. I have never heard that any brine spring had its source in this series of strata, though red sandstone in which gypsum abounds seems a likely locality for rock salt; and notwithstanding water impregnated with salt is a common product of the Newcastle coal field.

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* See Vol. 4, page 2, Transactions of the Geological Society.

† See Geol. Trans. Vol. 4, page 3.

On quitting the country just mentioned, the eastern side of Yorkshire, bounding the coast from the Tees to the Humber, comprises three ranges of hills:

1. The eastern Moorlands, or alum-shale district.
2. The oolite limestone hills, rising to the south-west of Robin Hood's Bay.
3. The Wolds, composed chiefly of hard chalk.

In this order I shall attempt to describe them.

The eastern Moorlands rise abruptly from the vale of Cleveland, and continue to do so to the south of Gisbro', between which place and Ayrton, Roseberry Topping is a well-known land-mark for mariners on the German ocean, and measures, according to Colonel Mudge's computation, 1022 feet in height. Together with Danby beacon, and other hills of inferior elevation, it forms the northern escarpment of the Cleveland chain, which from thence declines towards the south till it reaches the vale of Esk, and is succeeded by the oolite limestone ridge.

The outline of the alum-shale district is extremely irregular. The immense bed of schistose clay just appears at the Salt Scar rocks, lying in the sea about two miles north of Redcar, which are covered by the tide at half flood. From this point it may be traced to the west of Gisbro'; then receding towards Newton and Ayton; after that bending to the east of Stokesby; from thence passing south-west to Arncliffe, and south to Cosley, till, in the vicinity of Thirkleby, its western limit is reached: but the coal mines near Easingwold, situated still farther south, appear to be worked in the upper strata of this formation. From hence it turns north-eastward, and at length terminates on the coast below Scalesby, south of Old Peak. The general inclination of the shale, together with the strata reposing upon it, is towards the south-west, and their dip at the rate of about 1 in 100. Fig. 1, Plate 38, represents a section of the strata from the Yorkshire Wold to Easington height.* On the north side of Whitby harbour they appear to be depressed by a downcast dyke about 90 to 100 fathoms. Fig. 2, 3, and 4, (Plate 38) are sections on a large scale of particular places.

The alluvial soil lying upon the rocky beds is in many places from 50 to 100 feet thick, and contains large blocks of granite, sienite, porphyry and grauwacke, the wreck of mountains situated far to the west.

Immediately below this superficial covering, a thick stratum of sharp-grained sandstone is met with, in which considerable quarries have been worked on the banks of the Esk, and enormous blocks shipped for London, where it has been used for the interior structure of Waterloo bridge, the exterior being built with Cornish granite.

Alternate beds of bituminous shale, sandstone, and ironstone, succeed the sandstone; and from this repository, numerous fragments and nodules of argillaceous iron-ore are detached by the action of the sea, and lie scattered on the beach at the foot of the cliffs.

From hence the Tyne Iron Company have for some years past supplied their furnaces with large quantities of this species of ore. The same kind of ironstone is now calcined at some of the alum works as a material in the manufacture of Roman cement.

This thin coal formation covers the alum-shale, except where it bassets out, or is exposed to view by deep ravines, chiefly worn by the action of the water; and it dips in different directions according to situation, or, in other words, forms a basin. Towards the north, the dip is to the south-west; but at Coxwold, to the east. The thickness of the coal varies from 6 or 7 to 14 inches, but, to use the pitman's phrase, is frequently *nipped* out; the beds of sandstone meeting, and not leaving a vestige of the coal. In the swellies the seam is thickest, and best in quality. This stratum, with its accompanying thil, when it does occur, is situated between the white or grey post and the white freestone, the former of which is about 1½ foot, and the latter 21 feet thick. This thin coal formation upon the alum-shale undulates with the surface, which is not the case in the Newcastle coal field.

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* For this, besides much other valuable information, I am indebted to the kindness of Mr. Bird.

A bed called the *dogger* rests upon the alum rock. It is a hard sandstone, containing a considerable quantity of iron. Its thickness is from 7 to 13 feet, and colour a dark grey iron-grey, containing rounded pebbles of the same substance, together with numerous small grains of shining smoke-grey quartz, and specks of white disintegrated felspar. Ammonites, belemnites, and trigonia clavellata, are occasionally imbedded in it.

To this succeeds the enormous bed of alum-shale, from which alum has been manufactured ever since the days of Queen Elizabeth. The depth to which this stratum reaches has never been ascertained; but to give an idea of its thickness, I need only mention that the cliffs at Bowlby are 600 feet high, 400 of the lower part being an entire mass of shale: and to what depth it may descend below the level of the sea remains to be proved.

The upper part of the stratum of alum-shale is less compact than the lower, and containing a greater quantity of pyrites, produces more alum. Its colour is iron-grey; and as large heaps continue to burn till the whole mass is reduced to reddish-grey ashes, when once ignited by a small quantity of brushwood, I suspect some portion of bitumen must be blended with it.

For the process of manufacturing alum, as practised at present, I beg leave to refer to the Appendix to Aikin's Chemical and Mineralogical Dictionary.

At the time when the history of Whitby was published, alum works were carried on at Loftus, Boalby, Kettleness, Sandsend, Eskdaleside, Littlebeck, Stoupbrow, and Peak, but had previously been discontinued at Gisbro', Ayton, Carlton, Osmotherly, and other inland places.

At the depth of 200 to 250 feet from the top of the bed of alum shale, it is intersected and mixed with layers of sand for the space of 50 to 70 feet in thickness. These bands of sand are blended with clay, and contain nodules of thin bands of ironstone, in one of which large pectenites are found; in another a species of oyster; and in a third a shell resembling a cockle. This admixture of sand and clay is observable in the cliffs wherever the alum rock is exposed to view. Besides the fossils enumerated, madreporite, (See Jameson, edit. 2d, and Aikin's Min.) with liquid bitumen, occurs in this rock; and the tusks of sharks are occasionally scattered through it.

The following Sinkings for Coal at Baysdale, 12 miles west from Whitby, will illustrate the nature of these Beds.

No. 1.

	Yds.	ft.	in.
Sand and gravel	1	1	4
Brown sandstone	1	—	—
Metal	1	—	—
White freestone	1	1	6
Blue metal	1	—	—
Blue bind	0	1	6
Blue metal	1	—	—
Blue flinty stone	—	1	5
White freestone	3	1	6
Blue metal	1	1	6
White freestone	9	—	—
Blue metal	—	1	—
White freestone	1	1	6
White freestone	5	1	6
Blue metal	1	—	—
White freestone	—	1	—
Blue metal	—	1	4
White freestone	—	—	6
Blue metal	—	1	6
White freestone	3	2	2
Yards	40	—	—

No. 2.—Sinking.

	Ft.	in.
Walling from the surface	10	6
Drab-coloured stone	19	6
Blue metal	34	6
White freestoue	4	4
Blue metal	9	—
White post	1	8
Blue metal	6	—
Here Coal was expected		
White freestone	21	—
Feet	106	—

Boring from the bottom of the pit.

	Ft.	in.
White freestone mixed with blue whin	12	—
Bag stone	20	—
Alum shale	15	—
Feet	153	—

No. 3.—Boring.

	Fth.	ft.	in.
Peat moss	—	4	—
Blue clay	1	—	—
Blue metal	—	3	—
White freestone	—	1	6
Blue bind	1	4	6
Blue metal	—	1	6
White stone	—	4	—
Blue stone with coal pipes	1	—	—
Fathoms	6	—	6
brought over	6	—	6
Blue metal with post girdles	1	—	—
White freestone	—	4	6
Blue raggy stone	—	4	6
Dark brown post with water	1	3	0
Blue metal mixed with ironstone balls	—	4	—
Fathoms	10	4	6

Left off at a coarse white post with a large feeder of water.

Section of the Engine pit in Newbury Park Colliery, the Seat of the late Lord Falconberg, near the village of Coxwold, Yorkshire.

	Fth.	ft.	in.
Soil	1	—	—
Blue metal	—	4	6
Soft blue metal	5	—	—
Strong grey metal with cat heads	—	1	—
Coarse strong grey post	1	1	—
Coal	—	1	4
Fathoms	8	1	10

The Seam of Coal is of irregular thickness; seldom under 10, or about 16 inches. It dips to the East 2 or 3 inches per yard. The Coal is of an inferior quality.

Section at Gillingmoor, near Helmsley.

	Fth.	ft.	in.
Limestone	3	—	—
Freestone	6	—	—
Blue plate	3	—	—
Hard blue stone called galliad	—	2	—
Blue plate	2	—	—
Coal	—	—	—
Soft stone and plate	10	—	—
Blue limestone	1	1	—
Soft stone plate	1	1	—
Strong grit, blue mixed with red	17	—	—
Soft blue plate	2	—	—
Strong plate nearly black	10	—	—
Soft blue stone	2	—	—
Fine soft plate	—	2	—
Coal	—	—	6
Black Hull (Thil)	—	2	—
Yards	60	0	0

Section at Gerick Howl. on Skelton Moor.

	Yds.	ft.	in.
Blue shale	8	—	—
Sandstone with coal pipes	10	—	—
Blue plate and stone	10	—	—
Hard girdle stone	1	—	—
Blue stone and plate	30	—	—
Yards	59	—	—

At Sealing Dam bored 70 yards in beds of Stone similar to the above.

Boring at Osmotherly Moor.

Freestone	10	—	—
Blue plate	4	—	—
Red grit	2	—	—
Soft blue plate	—	2	—
Coal	—	—	6
Freestone	40	—	—
Yards	56	2	6

After this the borers appear to have kept no regular account, but say they bored 50 yards deeper through alternate beds of blue plate and soft stone, each bed being from 18 inches to 2 feet thick; and were in a soft white stone when the undertaking was discontinued.

A stratum of blue limestone containing iron, from nine to ten feet thick, crops out at Cold moor, four miles south of Stokesby. It is not met with in the cliffs at Whitby, where the borings were made twelve miles inland from that place, nor at Coxwold; and therefore cannot be a bed in the thin coal formation. The dip of the strata of Coxwold is different from that on the coast.

About three miles south of Robin Hood's bay, a lower range of round topped hills rise to view. This district consists of alternate strata of soft yellowish sandstone and oolite limestone, which rocks decline in the same direction as the alum slate, till they reach the vale of Derwent, where the oolite is covered in turn by the hard chalk.

The oolite, which may be seen cropping out at Filey head, Pickering, Kirby moor-side, and Helmsley, is a pale yellow, or yellowish-brown limestone; some of its beds, comprising numerous bivalve shells and other marine exuviæ. It is used as a building stone, and with this material York Minster and other edifices in the neighbourhood are constructed. When in a state of disintegration from the action of the air and rain, it becomes valuable to the farmer as a manure; but when burned does not make good mortar.

On the sea beach near Scarborough, numerous masses of pea-iron ore lie dispersed, and the same curious mineral occurs *in situ* among rocks of this series in a ravine south of the town. This locality, which is the only one I am acquainted with in Britain, agrees exactly with the formation where it abounds in France, according to the testimony of Brongniart (see vol. i. p. 170). Jameson says, this species of ore, which is met with in Germany, Switzerland, and Dalmatia, yields from 30 to 40 per cent of iron. The Tyne Iron Company used formerly to collect it in large quantities for their works at Lemington. Its colour is bluish-grey, and the grains or globules of which the mass is composed, vary from the size of mustard seed to those of large peas.

In the vale of Pickering, and even as far west of Thirkleby, a hard shell-limestone is quarried. Its situation appears to be subordinate to the oolite and sandstone; for at Thirkleby it bassets out at no great distance from the alum-shale formation. It is of a pale bluish colour, close grained texture; fracture slaty when broken, with large fragments; lustre glimmering (probably from numerous minute fragments of shells); and containing small bivalves. When weathered it becomes externally rusty brown. It is sonorous, and breaks into tabular fragments.

The Yorkshire wolds are undulating hills occupying a considerable part of the south and south-west, the district of Yorkshire to which our observations are confined. These commence on the Derwent, and stretching southwards, dip under the alluvial soil which covers the flat country in the vicinity of the Humber.

Hard chalk is the prevailing rock through the whole of this part of the district, and the high cliffs at Flamborough head serve to convey a just notion of its thickness. With the exception of iron pyrites this chalk does not appear to be metalliferous, but nodules of grey flints frequently occur in it.

Here it may not be amiss to mention that the same species of rock skirts the sea shore below Lowth in Lincolnshire, and there rests upon numerous beds of ash-grey bituminous shale, which crop out towards the west. When burnt, this shale emits a fetid odour, which I thought might arise from animal matter, as it is filled with the fragments of small bivalve shells, but on analysis no ammonia was detected.

Among the rejectamenta of the sea on this coast, fragments of a peculiar kind of coal abound, resembling the brown or Bovey coal in structure, but in colour being black as jet. Seams of this fossil are suspected to exist between the strata of bituminous shale before mentioned.

On the Yorkshire beach, common and jasper agates, together with resplendent felspar, are collected. These must be the products of the Northumberland and Scotch mountains, where amygdaloids and porphyries are the predominant rocks.

Of the organic remains in this district, the first particularly worthy of notice are the tusks and teeth of the Siberian elephant or mammoth, and which are not mineralized, but remain in their original state. Tusks supposed to belong to the same species of quadruped, have been found on the coast near Scarborough.

The mineralized skeletons of animals formerly supposed to be those of alligators, occur in the Whitby cliffs. One of these was noticed in the year 1758, by Capt. William Chapman, and his account is printed in the Philosophical Transactions, at p. 688, and that of Mr. Wooller, at p. 786, plate 9, fig. 5. From the vertebræ, which I had the opportunity to examine, I make no doubt but these bones belonged to the same species of animal as the one found in the lias between Lyme-Regis and Charmouth, on the Dorsetshire coast, and accurately described by Sir Everard Home, in the same publication, at p. 571, and pl. 17, 18, 19, 20, and since called by him Proteo-saurus.

The following petrefactions in the alum-shale are also worthy of notice :

Echinus vulgaris . . .	Parkinson, vol. 3, tab. 2, fig. 3.	
Ammonites serratus . .	Sowerby,	tab. 24.
. . . . armata . .	Sow.	tab. 95.
. . . . . . heterophillus	Sow.	tab. 166.
Nautilus lineatus . . .	Sow.	tab. 41.

Nautilus imperialis . .	Sowerby	tab.	1.
. . . . . discus . . .	Sow.	tab.	12.
Modiola depressa . . .	Sow.	tab.	8. mid. fig.
Orthocera conica . .	Sow.	tab.	6. fig. 1 & 2.
Belemnites			
Mya . . . . 2 species			
Chama digitata . . .	Sow.	tab.	174.
Helix			
Trigonia			
Pentacrinite			
Pectenite resembling the common scallop.			

These are all mineralized by clay ironstone, iron pyrites, and calcareous spar.

Gigantic reeds resembling arundo donax, are found in the sea cliffs opposite High Whitby. They appear to have been rooted in a bed of shale or slate clay, and their remains protrude into a stratum of sandstone five feet thick. Those which stand erect retain their shape, but those which do not are compressed. Their tops seem to have been broken off; the woody matter has disappeared, leaving sandstone casts. Casts of Euphorbiæ are also found in the sandstone strata above the alum rocks. Wood mineralized by iron is frequently found at Kettleness and Snowbrow. Trunks and branches of fossil trees, the bark and softer parts of which have been changed into jet, are frequently met with in the alum-shale; and leaves and impressions like those of the palm, are found in the sandstone and ironstone.

Galena is met with occasionally in nodules of the latter mineral; and hair pyrites (Sowerby, tab. 28) is found, though rarely, at Kettleness.

In the oolite at Malton and other places in that neighbourhood, enormous casts of ammonites, similar to those found in the west of England, occur in abundance.

Pinna marina—in sandstone, Troutsdale.

Trigonia clavellata—Parkinson, vol. 3, p. 12, f. 3, limestone, Pickering.

Nautilus nobilis—Malton.

Cardium resembling C. edule—Malton.

Ostrea edulis?—Malton and Pickering.

O. diluviana—Park. vol. 3. pl. 15. fig. 1. on the sands.

Solen ensis—on the Sands.

Bivalve, Park. vol. 3. p. 13, fig. 4. on the sands.

Terebratula coarctata?—Park. vol. 3, vol. p. 16, fig. 5.—in sandstone at Malton.

Mytilus edulis?—Troutsdale in sandstone, and Malton in limestone.

A small rivulet called Peacham beck, brings down a magnetic iron-sand, most probably Iserine.

A short distance below the town of Yarm, a basaltic dyke crosses the river Tees, in an east-south-east direction; and basaltic eminences may be traced in the same line by Stainton, Newton Danby, Derwent head; and terminate at Blea hill, in Harwood dale, seven or eight miles north-west from the coast. But whether these masses have any connection with the dyke it is impossible to ascertain.

That it is really a dyke where it crosses the river Tees appears very evident; but in the moorlands I suspect the low eminences of basalt are similar to those at Shewingshield in Northumberland.

It may be here observed, that the basaltic dykes in the Newcastle coalfield are known to terminate abruptly; for instance, those at Coley hill and Walbottle Dean, noticed in my former paper, are not found in the mines situated a short distance to the east of those places ; nor is the dyke known in Walker colliery detected in any of the mines adjoining.

The rock where it is quarried for mending the roads in the vicinity of the Tees is of a dark iron-grey colour, and fine grained texture. It consists of blocks, lying horizontally and coated with ochre, as is also the case at Coley hill, and various places in Northumberland. Where the dyke crosses the Pickering road at Sill Howell its texture is fine grained.

XXX.—*Notice of the discovery of a new Fossil Animal, forming a link between the Ichthyosaurus and Crocodile, together with general remarks on the Osteology of the Ichthyosaurus;*

from the Observations of H. T. De la BECHE, Esq. F.R.S. M.G.S.

AND

The Rev. W. D. CONYBEARE, F.R.S. M.G.S.

DRAWN UP AND COMMUNICATED BY THE LATTER.

[Read April 6, 1821.]

IN the course of a series of observations on the organic remains contained in the lias in the vicinity of Bristol, my attention was particularly attracted by the numerous vertebræ of oviparous quadrupeds occuring in that formation. Of these a considerable portion obviously belonged to the Ichthyosaurus; the remaining, and larger division, presented vertebræ of forms considerably differing from each other, but which, from some general analogies, I was persuaded had all belonged to different places in the vertebral column of a single species; and I ventured even to point out those places, from a comparison with those of the crocodile to which they bore a strong general resemblance, yet at the same time combined with so many material points of difference, as to prove that the animal from which they were derived must have constituted a separate genus.

At this period, I was fortunate enough to associate in my researches a colleague equally able and zealous, whose name stands at the head of this paper. The numerous important and illustrative specimens which he placed at my disposal, proved of material aid, and still more so his general acquaintance with the subject, of which I subsequently enjoyed the fullest advantage; so that the facts now submitted to the Society must be considered as the fruit of inquiries prosecuted by us in common.

A skeleton of the animal in question, deficient only in the bones of the head, preserved in the well known collection of Col. Birch, (who most liberally allowed us the full use of the very valuable materials he possessed)* confirmed in a most satisfactory manner most of my previous conjectures, and enabled us to assign to it its true place in the zoological order, and to designate it by an appropriate name. That of *Plesiosaurus* has been chosen, as expressing its near approach to the order Lacerta.

The points of analogy between the newly discovered animal and the Ichthyosaurus are sufficiently numerous and important to evince the propriety of their being referred to the same great natural family, a family on every account highly deserving an attentive examination, its members being not only unknown in the recent state, but presenting many peculiarities of general structure, of which no other examples had been previously observed; and of that most interesting description which affords intermediate forms, and as it were a transition between different races, and adds new links to the connected chain of organized beings.†

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* I have also to acknowledge our obligations on similar grounds to Mr. Bright, Dr. Dyer, Messrs. Miller, Johnson, Braikenridge, Cumberland, and Page of Bristol.

† When alluding to the regular gradation, and, as it were, the linked and concatenated series of animal forms, we would wish carefully to guard against the absurd and extravagant application which has sometimes been made of this notion. In the original formation of animated beings, the plan evidently to be traced throughout is this. That every place

The family, then, to which we would thus refer the animals above mentioned, and to which future researches may be expected to add other analogous genera,* may be described as including animals approaching more closely to the Saurian or Lizard family, and especially to the genus Crocodile, than to any other recent type; yet receding from it in many important characters, especially in the form of their paddles, which possess an intermediate structure between the feet of quadrupeds and the fins† of fishes, and have been well distinguished by the above appropriate name. As these

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capable of supporting animal life should be so filled, and that every possible mode of sustenance should be taken advantage of; hence every possible variety of structure became necessary, many of them such as to involve a total change of parts, but others again, such as required nothing beyond a modification of similar parts, slight indeed in external appearance, yet important in subserving the peculiar habits and economy of the different animals; in these cases the unity of general design was preserved, while the requisite peculiarity of organisation was superinduced; nor can there be any where found a more striking proof of the infinite riches of creative design, or of the infinite wisdom which guided their application. Some physiologists however (and Lamarck is more especially censurable on this account) have most ridiculously imagined that the links hence arising represent real transitions from one branch to another of the animal kingdom; that through a series of such links, and by means of the constant tendency of the vital fluids, urged by animal appetencies to perfect old organs and develop new ones, that which was once a polypus became successively a mollusca, a fish, a quadruped; an idea so monstrous, and so completely at variance with the structure of the peculiar organs considered in the detail (which is in the great majority of instances such that no conceivable appetency could have any conceivable tendency to produce it) and no less so with the evident permanency of all animal forms, that nothing less than the credulity of a material philosophy could have been brought for a single moment to entertain it—nothing less than its bigotry to defend it.

* I do not intend here to include those fossil animals, which are clearly only distinguished by specific characters from the recent crocodiles, but those which, though approximating more closely to this than to any other type, are yet marked by generic and essential differences.

† The analogy of these paddles to the fins of fish consists in the number, not in the form of the joints composing them. In many respects, as will hereafter be shewn, they approach most nearly to the paddles of the turtle.

animals appear unquestionably to have lived, principally at least, in the sea, and to have received the peculiarities of organisation to which we have alluded, in order to fit them for such an habitation, the term *Enalio-Sauri* may be proposed as a classic appellation to denote the whole order. Of the genera composing it, the Ichthyosaurus recedes most widely from the forms of the lizard family, in order to approach those of fishes; but it is still incomparably nearer to the former; and a careful study of its osteology presents, as will presently be seen, a beautiful series of analogies with that of the crocodile, in all the most essential parts.

The newly discovered animal, named on that account Plesiosaurus, approaches much more nearly to the crocodile, forming in its whole structure, a link between it and the Ichthyosaurus; hence it acquires a high and peculiar interest, as affording a middle term of comparison, illustrating the reciprocal relations of both, and often shewing a real connexion between them, by exhibiting an intermediate gradation of form in parts, which would, at first sight, appear the least likely to be reconciled.

Of these animals, the Ichthyosaurus has already engaged a considerable share of attention among the scientific public, having been illustrated by a writer whose name stands deservedly high among the comparative anatomists of this country. Yet, since the materials from which his descriptions were drawn up came only into his possession gradually, and were with a praise-worthy readiness communicated instantly to the public, the circumstances of the case rendered it impossible to attempt a regular and connected view of the whole osteology of this animal, and a series of detached essays on such individual points of its structure as the specimens happened to present, was all that was practicable; hence many of the most important parts of the skeleton, the whole osteology of the head for instance, cannot be said as yet to have been in any degree elucidated; the analogies by which its place in the natural kingdom must be determined, though ably pointed out, are far from having been fully unfolded, and a precise anatomical description of its general structure remains a desideratum.

The great subsequent accumulation of materials, which must be doubtless in a great measure attributed to the researches above alluded to, and more especially the numerous specimens contained in the many collections of this neighbourhood (Bristol) and in that of Mr. De la Beche, have afforded me, through the able assistance of that gentleman, the means of filling up the most material of the chasms in our information on the subjects which I have mentioned; and since the points determined are at once in themselves of considerable importance, and promise, from the analogies above stated, to afford considerable assistance in prosecuting our farther observations on the newly discovered animal, we shall preface the details concerning it, which we are about to submit to the Society, by a general and comparative view of the osteology of the Ichthyosaurus.

ICHTHYOSAURUS.

General characters. A marine quadruped, nearly resembling the crocodile, in the osteology of its head, and its mode of dentition. Vertebræ having both faces of their body deeply concave as in fishes. Extremities having no distinct radius and ulna, but the humerus immediately supporting a very numerous series of small polygonal bones, forming a very flexible paddle. Anterior extremities much larger than the posterior.

We have retained in these observations the name Ichthyosaurus, originally applied to this animal by Mr. König of the British Museum, feeling convinced that on a full and careful review of its whole structure, it will not be found to possess analogies sufficiently numerous or strong with the peculiar organisation of the Proteus to authorise the change of this appellation into Proteosaurus, as subsequently proposed.

Particular Observations.

Osteology of the Head.

a. *Teeth.*[*] These bear a near resemblance in form to those of the crocodile; and the mode of dentition by the young tooth growing up in the interior of the cavity of the old one, and when matured, splitting and causing it to fall, is exactly similar.

The teeth are more numerous than in the crocodile; there cannot be less than 30 on a side in either jaw: but from their irregular growth, their partial concealment in the stone, and difficulty of finding complete jaws, they have not yet been accurately numbered.

They are placed in a long sulcus, formed in the maxillary and intermaxillary bones, like that in the jaw bones of some fishes, not in separate alveoli, as in the crocodile.

b. *Lower Jaws.* In order to demonstrate the close relation between the Ichthyosaurus and the lacerta family, it is necessary to premise, that the lower jaw in that order, instead of having, like other quadrupeds, a single bone on either side, exhibits no less than six of these; one called the dental, which carries the teeth, forms the whole anterior extremity of the jaw, and continues to cover the upper portion, and to lap over the exterior; the rest of the outer face is formed, in the posterior part, by a second bone, the coronoid; the bottom by a third, the angular; and the inner face by a fourth, the opercular; in addition to these four bones, the articular, which is placed at the posterior extremity for the purpose which its name denotes, and a small crescent-shaped bone, which sometimes forms the coronoid process, complete the stated number.

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[*] From the different forms of the teeth alone, three species at least of the Icthyosaurus may be ascertained; but they differ only in very slight points, and not in any that very materially affect the general form and structure of parts to which it is our intention to confine ourselves in the present paper. Hereafter we propose a further communication on this subject.

Of these bones, we have succeeded in demonstrating the five first on the Ichthyosaurus, occupying situations closely corresponding to those which they possess in the crocodile. The crescent-shaped bone is the only one of the series which we have not yet detected; and this probably arises from our never having seen the part of the jaw in which it occurs fairly exposed.

Almost the only differences from the lower jaw of the crocodile are, 1st, the apparent absence of the oval hole* just behind the termination of the dental bone, which characterises the latter, but which is however not to be found in others of the lacerta family; and, 2dly, which is more important, that the bones are not connected by common but squamous sutures, forming plates folding over one another, as in fishes.‡ This structure, which combines

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* In one beautifully perfect specimen of Ichthyosaurus, belonging to Mr. de la Beche, a sulcus communicating with a small foramen may be seen in a similar situation. We have not however traced it as yet in others; but it is so situated as to be readily concealed, by being filled up with the stony incrustation.

‡ This overlapping mode of application, or as it is technically termed, squamous suture, occurs also in most of the bones of the head; since by the accidental removal of portions of the external bones, more or less of the internal, against which they are in consequence of this structure applied, is often exhibited in different specimens, a correct idea of their outline can only be obtained by the careful collation of several such specimens in their ordinary state of preservation; and a single one can only be relied upon where it appears to be undoubtedly perfect and unmutilated, a circumstance which it requires some practice to ascertain.

The sutures of some of the bones (those particularly of the orbits) are singularly the greatest solidity and strength with the least weight of bone, is admirably calculated at once to increase the buoyancy of the animal, and to enable it to face the waves of an agitated ocean, and has doubtlessly been given to it to fit it for its marine abode.

The general form of the jaw differs from that of the crocodile in being much more lengthened and acutely angular; its termination is indeed almost as sharp as the beak of a bird.‡

The accompanying figures (plate 40, fig. 1 to 10) will explain the forms and arrangement of these bones better than any verbal description. In order to facilitate comparison with the analogous bones in the crocodile, we have employed the same letters with which M. Cuvier has marked the head of that animal, in his memoir on the fossil remains of oviparous quadrupeds: † viz. *u*, dental; *x*, coronoid; *v*, angular; &, opercular; y, articular.

The appearance and range of the dental, coronoid, and angular bones on the outer face of the jaw, are shewn in the side view of the head (Fig. 9. plate 40.)

The view of the lower jaw, as seen from *beneath* (fig. 10, plate 40) exhibits the course of these bones and the opercular throughout the jaw. The transverse sections numbered from one to eight (plate 40), the position of which is indicated by the dotted lines in the side of the head, fully elucidate the form of the several bones

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adapted for strength, being partly squamous and partly dovetailed, so that one bone is partly inserted into the other by a sort of angular process, on either side of which they overlap each other reciprocally. On these points we propose, in a future communication, to speak more in detail.

‡ Specimens exhibiting the termination of the jaw in an unmutilated condition are very rare; we are indebted to the kindness of Mr. Miller for one which displays that of both jaws in a perfect manner.

† Recherches sur les ossemens fossiles, tome 4.

and the changes they undergo in different parts of the jaw, from its anterior to its posterior extremity, and also the manner of their application to each other.

Bones of the upper part of the Head.

These have the same marked coincidence with those of the crocodile which distinguishes the bones of the lower jaw; they are shewn in the accompanying figures (pl. 40) fig. 9, 11, 12, marked by the letters employed by M. Cuvier. Since to describe them at length would be generally to repeat the words of that author, in treating of the structure of that animal (the crocodile), we shall confine ourselves to a rapid sketch, noticing principally the peculiarities of configuration by which the Ichthyosaurus differs from this type, most of which arise from the adaptation of the parts to the narrow and elongated contour of the whole. The eye also is rather lower placed than in the crocodile, the bottom of the orbit being nearly on a level with the line of the opening of the jaws; this produces some very slight changes in the form of the adjacent bones; and perhaps a still more important deviation occurs in the place of the nostrils; but this point still remains involved in some degree of obscurity.

We shall first consider those bones which appear on the sides and inner part of the mouth, as exhibited in figures 9, 11, and 12, plate 40. and in the transverse section fig. 3, of the same plate.

The general outline of the upper, like that of the lower jaw, is much more pointed than in any species of crocodile; its termination resembles that of the porpoise, the bones of the opposite sides opening at the end so as to form a narrow angular slit; this slit requires an attentive examination from the doubts that have arisen concerning the place of the nostril in this animal; the two openings generally to be traced in front of the orbits were at first thought to have discharged this function, but Sir Everard Home, having subsequently examined a specimen in which these apertures were externally closed, was induced to retract this opinion; and having observed that a passage supposed to form the nasal canal continued to the fore end of the snout, he indicated the propriety of looking for the nostril in that part, as in the crocodile. The examination of a specimen, in which the extremity of the snout is preserved in an entire and unaltered form, enables us to determine positively that the canal in question terminates in the narrow slit above described, and that there is no other opening whatever in this part. We still however feel great hesitation in considering this as the true nostril, since it is so minute as to be out of all proportion with the size of the animal, and we cannot feel quite satisfied that some forced and false position of the bones in the single skull alluded to may not have covered unnaturally the openings before the orbit, at first supposed to be nostrils; since in every other specimen we have examined, amounting to nearly twenty, they appear to be well defined and perfectly open.

The intermaxillary bones, *a*, *a*, run much farther back than in the crocodile; a variation partly arising from the prolonged form of the snout. Owing to their overlying the maxillary bones along the line of their junction, it is often difficult to distinguish them, especially as they leave only a very small portion of the latter exposed on the outer side of the jaw; they have also an overlying application against the nasal bones. These and the maxillary bones, *b*, *b*, further differ from those of the crocodile (in common with those of the lower jaw), by carrying the teeth in an open sulcus instead of separate alveoli. The maxillary bones are also more confined to the back part of the jaw, and broader and flatter at their posterior extremity, where they underlie the orbit, and are slightly curved to fit them for their situation. In the roof of the mouth, the maxillary bones, receding from each other as they advance towards the posterior parts, exhibit, (as seen in fig. 3 & 12, plate 40.) the palatals, *e*, *e*, which closely resemble those of the crocodile, but are still longer and narrower.

Between the posterior terminations of the palatal and maxillary bones, is an opening, as in crocodiles, but more elongated and narrow; this opening in the crocodile is surrounded on the posterior side by the pterygoid processes, *f*, *f*, and a peculiar bone, *d*, which may be considered as an external pterygoid process intervening between the preceding and the maxillary bone on either side. This structure, considered I believe, as peculiar to these animals, is also to be observed in the Ichthyosaurus, where the peculiar bone, *d*, will be seen resting against the inside of the termination of the maxillary, and extending in a long process to the hinder extremity of the head. Of the pterygoid processes *f*, *f*, traces only have been as yet discovered, too much broken and distorted for representation, but quite sufficient to shew that they nearly agreed with those of the crocodile.

Having thus described such of the bones as occur in the roof of the mouth, we proceed to those which occupy the external part of the face. The nasal bones, *k*, *k*, are placed as in the crocodile. Between the nasal bones and the posterior extremity of the maxillary bones, *b*, *b*, lie the lacrymal bones, *i*, *i*; these form the anterior margin of the orbit in its lower part; in front of these bones are placed the oval openings before alluded to as is generally to be observed in all the skulls of this animal yet found, with a single exception, which at first (and as we still think with much probability) were supposed to have been the nostrils. We have already stated our reasons for doubting whether the contrary evidence, arising from the single specimen in which these apertures appeared to be closed externally, was quite sufficient to invalidate this supposition. If however it should eventually be proved that these openings are actually closed in perfect specimens, which, although we have yet failed in tracing the fact, may nevertheless not impossibly take place, in consequence of the prolongations of the intermaxillary and anterior frontal bones folding over them; (since the common mutilation of the extremities of those bones might certainly account for the present exposure of these openings: *)—in that case the narrow slit at the fore end of the snout must be the true nostril, and these oval foramina must be the openings of the lacrymal into the interior of the nasal canal, exposed by this accidental removal of their external covering; a supposition which will agree very well with their place in front of their lacrymal bones; they are represented by dotted spaces in the accompanying figures.

We have now described all the bones of that part of the head which is anterior to the orbit, and forms the snout of the animal.

The frontal part of the head consists of five distinct bones; the middle frontal, H, which extends between the orbits, the anterior frontals, *h*, *h*, which form the upper anterior portions of the orbit, and the two posterior frontals, *h'*, *h'*, which by their post-orbital processes *h''*, *h''*, form the upper and posterior margin of the orbit, and complete it by uniting with the jugals, *c*, *c*, which form its lower part.

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* Since this paper went to press we have seen specimens which decide that this aperture was also perforated through the end of the intermaxillary bone, and consequently must have been open externally; the necessary conclusion is, that the appearances in the single skull, described by Sir Everard Home, must have been deceptive, and that the only objection to considering these apertures as the nostrils is removed.

The only difference in these respects is, that the post-orbital process *h''*, *h''*, in the Ichthyosaurus, does not, as in the crocodile, bend inwards, but meets the jugal *c*, in the line of the general curvature of this part of the face, so that the margin of the orbit is nearly of the same curvature throughout, and the jugal bone *c*, in consequence of the lower situation of the eye, is much reduced in size.

We have now arrived at the bones which are behind the orbits and over the summit of the cranium, corresponding in situation to the parietal bones of other quadrupeds.

Here again the crocodile has a peculiar structure, this part of the head being distinguished by two large oval openings not unlike those of the orbits, but rather smaller, which may be called from their situation the super-parietal cavities. Between these cavities is the bone *m*, answering to the single parietal of ruminants, the bones marked *n*, *n*, considered as answering to portions of the temporal bones form their posterior angles, and by uniting with the lateral frontals *h'*, *h'*, complete the enclosure.

All these strongly marked characters occur without any material deviation in the Ichthyosaurus.

The last bones of the head we shall describe are those which interpose between the jugal *c*, and the last mentioned bone (*n*), and which together with it, are considered as making up the remainder of the temporal; the first of these, *o*, which bears at its inferior and hinder extremity the condyle for articulation with the lower jaw, may be observed placed in the Ichthyosaurus, as in the crocodile, namely, extending from the lateral frontal *h'*, towards *n*, to a process of which it joins; *p* is interposed between this and the jugal bone *c*, and thus completes the enclosure of the temporal fossa, which seems to have been narrow in this animal.

We have not yet been fortunate enough to find a specimen which would permit us to examine the bones of the hinder and inferior portions of the skull; but the osteological details we have already submitted must be considered as placing in the fullest light of demonstration the near alliance of this animal, and its almost identical structure, with the crocodile.

The eye of this animal has its sclerotica, as is well known, composed of a long or rather scaly substance subdivided into thirteen plates. I have now before me the eye of a middle sized lizard from Germany, which has a structure exactly similar, excepting that the plates are more numerous.* The chamelion, iguana, and tupinambis, have similar osseous laminæ, as has the tortoise, but in this latter animal they form, as in birds, the anterior disk.

A fossil animal found at Milenhart, near Dettingen, in the district of Manheim, and described in the Munich transactions under the name Lacerta gigantea, which closely resembles, if it be not identical with, the Maestricht animal, has evidently the same structure.

Vertebræ.

Although throughout the bones of the head, so close an analogy has been found to prevail between the Ichthyosaurus and Crocodile, the vertebræ are widely different, and much more analogous to those of fishes, having, like them, in consequence of the double concave form of their bodies, the inter-vertebral joint deeply cupped

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[*] This was pointed out to me by Mr. Miller, to whose assistance I have otherwise been much indebted, and who by the scientific spirit and unwearied perseverance which he has applied to the illustration of the comparative anatomy of organic remains, promises to accomplish many interesting discoveries in that branch. His work on Encrinital remains, when submitted to the public, will form a model of sagacious, patient, and successful research.

as Sir E. Home has well observed: he has also fully described the peculiarity of their spinal canal, the annular part not being consolidated with the body, as in quadrupeds, or connected by a suture as in Crocodiles, but remaining always distinct and united by a peculiar joint. The figures will sufficiently explain the form of the annular part and the joint in question; this structure is believed to be peculiar to the Ichthyosaurus.*

The absence of transverse processes, and the consequent articulation of the ribs to the body of the vertebræ by double lateral tubercles is another important distinctive feature.

Their narrow form, or in other words, the small proportion which the length of the side of their body bears to the diameter of its articulating surface, is another good and ready criterion. In the Ichthyosaurus, the length of the side is less than half the diameter; in the vertebræ of a true fossil Crocodile found at Gibraltar in Oxfordshire (the same apparently with the 2^d fossil species of M. Cuvier,) it slightly exceeds the diameter; and in the Plesiosaurus, which holds an intermediate place in this respect, the ratio of the length of the side to the diameter is never so small as one half, and never so great as equality. Although the proportions may slightly vary in different parts of the column, the change is not sufficient to affect this general expression.

The total number of vertebræ has not been ascertained, but it cannot be less than between eighty and ninety, that number being exhibited on the specimen figured in the Phil. Trans. for 1819, and as several are there displaced, it is probable that some are missing.

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* This mode of articulation of the annular part of the vertebræ with their bodies, by a regular joint, was necessary to cooperate with the cupped form of the intervertebral joints, in giving that flexibility to the vertebral column which the vibratory motions necessary in the mode of progression, which seems to have been common to this animal and fishes, required: for had these parts been consolitated as in quadrupeds, their articulating processes must have locked the whole column together so as to render such a motion of its parts impossible, but by means of this joint every part yields to that motion.

The changes in their structure corresponding with and indicating their places in the vertebral column, are represented in the accompanying figures from a nearly entire column in the possession of Colonel Birch.

The atlas and axis* have not yet been clearly ascertained; but there seem to be traces of them in the first bones of the column in question. At any rate, it is highly improbable that more than one or two of the anterior vertebræ can be missing (if any are so) in that specimen. The numbers attached to the figures (fig. 12, plate 41,) indicate their place in that series.

The seventeen first have but one tubercle; they are farther distinguished by the broader and peculiar form of the sockets into which the annular part articulates, which in all the remaining ones is straight and narrow. The third vertebra has been selected as a specimen of these, and the seventeenth or last of them to shew the transition to the next form; these are evidently cervical and anterior dorsal.

The false ribs and ribs connected with these vertebræ must have articulated by a double head, partly against the tubercle, and partly against the cavity left by the prolonged lip of the socket into which the annular part of the vertebræ is set.

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* We have seen only the inferior piece or body (if it can be so called) of the atlas; and the odontoid process (which as in all the reptiles forms a distinct piece) of the atlas; they very nearly resemble those of the turtle; but we refrain from figuring them till we shall have seen the parts entire. There seem to be some specific differences in the form of the tubercles in different vertebral columns of the Ichthyosaurus, perhaps they may also be affected by age; they are not however such as to affect the general arrangement and position of them as described in the text; all the small specimens which we have seen, which are generally the most sharply marked, agree with those we have figured.

The twenty succeeding vertebræ have two articulating tubercles to support the ribs, and must be assigned to the middle and posterior dorsal and lumbar. The upper of these tubercles is at first placed close to the lip of the annular socket, and thence assumes gradually a lower and lower position on the side, so as to approach more nearly to the inferior; at length near the fortieth the two tubercles run together and form a single ridge.

The 18th, 25th, and 38th, have been selected for representation, as exhibiting the mean form of these vertebræ and their passage into the adjoining forms on either side.

The changes of position in these points of articulation at once affected the sweep of the ribs in forming the cavity of the thorax and abdomen, and their motion in opening it in respiration.

The vertebræ hence to the extremity of the tail have no material change, excepting that the ridge formed by the union of the two tubercles, which at first stretches across the body obliquely, at length becomes horizontal. There are also two ridges across the bottom.

The ridges on the side appear to have supported those horizontal processes, which will be better seen in the caudal vertebræ of the plesiosaurus as analogous bones are usually found lying by the side of these vertebræ. The two inferior ridges probably supported the fork of the chevron-shaped bone which occurs in the tail of all the lizard tribe, though we have not yet actually seen it in this animal. The character of these vertebræ is represented by the forty-sixth of those from Col. Birch's specimen, and by one from the extremity of the tail exhibiting the annular part attached, belonging to Mr. Johnson.

Concerning the ribs, we have no new remark to offer, with the exception that a careful examination of many specimens has convinced us that they did not form a single continuous arc, as the appearance of a single specimen induced Sir Everard Home to believe, but consisted of separate ribs on either side with intercostal bones lying between them and attached to them by cartilages.

Bones of the Sternum and anterior extremities.[*]

These have been most correctly and beautifully represented in Phil. Trans. for 1817 and 1820, but it is with great diffidence that we venture to differ from Sir Everard Home in the analogies and names ascribed to the several parts.

In the first place, we may observe an arched bone having a flat process proceeding from the bottom of the arch. The whole form and apparent position in the skeleton is very analogous to that of the bone commonly called the merry-thought, and technically, the furcula, in birds,[†] but its inferior process is parallel instead of being at right angles to the lower part of the chest; in the ornithorynchus, however, the form of this bone entirely agrees with that of Ichthyosaurus.

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[*] In the text the appellation of clavicles has been assigned to those bones in the skeletons of the Orders, Reptiles and Birds, which are so denominated by M. Cuvier, in his memoir on fossil crocodiles, by Blumenbach, and the more common treatises on comparative anatomy. It has been suggested to me however that more recent observations seem to demonstrate the analogy of these bones with the coracoid processes of mammalia rather than with clavicles, and the furcula forms in fact the true representative of the latter. If this view be admitted, as it has successively been by M. Cuvier, it will be proper to substitute in the text the term coracoid bones for clavicles, and clavicular arch for furcula. The arguments on which the above changes are founded proceed from the consideration of the muscles originating in the bones in question.

[†] It may seem extraordinary to search for an analogy in the structure of animals of so widely different an order as birds, when treating of any part of the skeleton of a species intermediate between crocodiles and fishes; yet the general disposition of the arched bone, the scapulæ, and clavicles, is so very similar that it is impossible not to remark the resemblance; and when it is considered that the employment and motion of the paddle in swimming has many points of agreement with that of the wing in flight, "remigio alarum," we cannot be surprised that nature, ever œconomical in the application of her means, has given a similar structure to the parts adjacent to the anterior extremities in both instances.

The toad has a similar apparatus, but consisting of three distinct pieces; the inferior process and either arm of the arch forming a separate bone.

This bone alone we consider as belonging properly to the sternum; we shall therefore call it the sternal arch.

The inner side of the scapulæ is attached to the arms of this arch; in this it agrees most nearly with the ornithorynchus, in which however the extremities of the arch do not proceed the whole way behind the scapulæ, but only afford a small articulating face. In the toad, and birds, the extremities of the arch articulate between the scapula and clavicle.

The flattened hatchet-shaped bone, the narrow and excavated end of which unites with the scapula to form the glenoidal cavity, and which has been considered as analogous to the flat bones of the ornithorynchus, and peculiar to these animals, appears very obviously, on comparison with the corresponding parts of the crocodile, to be a true clavicle, differing only in its proportions, being shorter and therefore wider at the flattened end.

In the crocodile, the toad, and birds, the extremities of the scapula and clavicle unite in the same manner to form the glenoidal socket; and all agree closely with the Ichthyosaurus, except, as has been observed, in the shorter proportion and broader end of the clavicle in the latter. The flattened bones of the ornithorynchus should probably be also considered as substitutes for clavicles; but they deviate very widely indeed from the general form, although those of the Ichthyosaurus in some respects present an intermediate gradation.

The whole of this structure, the form of the sternal arch, and the broad surfaces of the clavicles, is such, as to impart great strength to the chest, enabling the animal to breast the most disturbed waters, and affording an extensive surface for the attachment of powerful muscles to assist in moving the anterior extremities.

The glenoidal cavity receives a bone which corresponds at once with humerus, radius and ulna, these parts being shortened in consequence of their adaptation to support an extremity corresponding, in its employment at least, rather to a fin than a foot. Somewhat similar takes place for the same reasons in the humerus, radius, and ulna of the porpoise, which are in like manner shortened and anchylosed; but still in that animal traces of their distinct form may be recognised.

This humero-radius supports the bones of the paddle, in which the first four or five rows may be considered as carpal and metacarpal, and the remainder as phalangic, although all the bones are nearly similar in form, being irregular flattened polygons. They are so disposed that the first row consists of only two pieces; the succeeding rows, as far as the fifth, which thus contains six, encreasing in arithmetical proportion; in some specimens eight may be counted in the succeeding rows; but the exterior pieces are very small and generally removed; in length there are about thirty-five of these rows, decreasing to a very small size near the end: the bones of the exterior series have a more rounded outline than the rest; the longitudinal series of these phalanges proceed in right lines from their base in the carpus; the two first bones of the carpal part much resemble that of the porpoise, and the two succeeding series present an absolute identity of form and arrangement with those of the turtle, to which, as we shall hereafter see, the paddle of the newly discovered plesiosaurus bears also throughout a very close analogy.

Bones of the Posterior Extremities.

Those of the pelvis have not yet been seen in a perfect state; but as Sir E. Home has stated, they closely resemble those of the Crocodile. The femoral bone and posterior paddle are altogether analogous to the humerus and anterior paddle; but, contrary to the posterior extremities of quadrupeds in general, very considerably smaller, nearly in the proportion of one to two; the reasons of this variation are obviously the same which lead to a similar diminution of the analogous parts in seals, and their total disappearance in cetacea; namely the necessity of placing the centre of the organs producing and regulating motion when acting laterally, before the centre of gravity.*

General Remarks.

From the dislocated and imperfect state of the skeletons of this animal, it is not easy to ascertain the relative proportions of the several parts; but from a careful examination of the most entire, it would appear that the head and jaws occupy about one fourth of the total length of the animal.

The size to which the animals of this genus sometimes attained may be inferred from a head in the possession of Mr. Johnson of Clifton, in which the longest axis of the orbit is 14½ inches.

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* This remark applies only to animals moving swiftly through a sensibly resisting medium; for the same reason the wings of birds are placed in the fore part of their body; and to turn to works of art, the centre of the moving forces given to ships by their sails is similarly placed; were it otherwise, a slight disturbing force near the head of the moving body, would instantly swing it round. The great organ of motion in fishes, the tail, is indeed posteriorly placed; but this by its mode of action generates a vis a tergo, which can only impel the animal straight forwards; and does not therefore operate under the same conditions with organs laterally applied.

Comparing the proportions of this head with that of the entire skeleton figured in Phil. Trans. for 1819, it must have belonged to an animal exceeding twenty-four feet in length.

The geological seat of these interesting remains is principally in the lias, and in the clay underlying the Portland oolite at Kimmeridge, and on Shotover hill, near Oxford; but they have also been found in some of the intermediate formations, e. g. in the calcareous grit underlying the Oxford oolite at Marcham near Oxford; and again in one instance in a formation still more recent than the Kimmeridge clay, namely in a bed of marle associated with the green sand series at Bensington in Oxfordshire, probably contemporaneous with that of Folkstone in Kent. On the whole, therefore, it appears that the occurrence of these animals is at least coextensive with the whole series of formations intervening between the new red sandstone and chalk: they seem however to be most abundant in the lias. We have seen specimens from numerous localities situated on that formation in Dorsetshire, Somersetshire, Gloucestershire, and Leicestershire.

It has been our object, in drawing up the preceding details on the genus Ichthyosaurus, to establish a firm foundation of anatomical knowledge, which might be applied to the illustration of the newly discovered genus plesiosaurus, to which it is obviously in many respects allied. For since, of the latter, comparatively few specimens have been yet accumulated, and those deficient in many important members, we are not as yet in a state to neglect the aids to be derived from such analogies.

To communicate a notice of the discovery of this new genus was the principal object of the present paper; yet, from the circumstances above mentioned, our details concerning it will necessarily occupy a far less space than those which strictly speaking were only preliminary. In this, as was strikingly exemplified in the history of the discoveries connected with the former genus, we doubt not but that an early and unreserved communication of materials, which from the circumstances of the case cannot but be imperfect, will soon lead to the removal of the present deficiencies, and for the reasons stated in the beginning of this memoir, we trust that what has already been ascertained, which indeed comprises the most material points connected with the trunk and anterior extremities, will not be found entirely devoid of interest.

PLESIOSAURUS.

General character. A marine animal, intermediate in its structure between the Ichthyosaurus and Crocodile.

Teeth. Not having as yet obtained a head of this animal, we cannot speak with certainty on this subject; but a peculiar tooth, not belonging to any species of Ichthyosaurus, yet evidently of the Crocodilian type, occurs in the lias, and may with great probability be referred to this animal.

Jaw and Head bones. Not as yet discovered.*

Vertebræ. These agree more nearly with the Crocodile than with the Ichthyosaurus; we shall therefore compare them with the former type; stating first their points of agreement, and then of difference.

They agree with those of the Crocodile in having their annular part attached to the body by sutures; those in the younger specimens allow the two parts to separate completely, and form a clean socket not unlike that in the Ichthyosaurus, but in the older specimens they are completely anchylosed: they farther agree in having transverse processes throughout the greater part of the dorsal vertebræ, which, together with the whole of the annular part, very nearly resemble the corresponding forms in the type alluded to. The principal differences are.

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* Since this paper went to press a few very imperfect specimens have occurred, which exhibit very little of an illustrative character, excepting that in this animal the teeth were carried in distinct alveoli, and not in a continuous sulcus, as in the Ichthyosaurus.

1st In place of being concave at one extremity, and convex at the other end, thus articulating by a species of ball and socket-joint, they are slightly concave at both extremities of their body, but again slightly swelling in a contrasted curve near the middle of the circular area. In these features however, though they differ from recent Crocodiles, they agree with one species, at least, of those found in a fossil state in England, France, and Germany; and all the fossil species appear to have this structure in the posterior part of the column.—(See Cuvier O. F. T. 4, and the description of Crocodilus priscus, in the Munich Transactions.)

2. They differ from both the fossil and recent species of Crocodile in much narrower proportions; though far less so than do those of the Ichthyosaurus. The proportion of the diameter to the length of the side being nearly as 5 to 4 in the cervicals, in the middle dorsals a little greater, and in the caudals nearly double; whereas, the mean proportion in the fossil Crocodiles we have examined is nearly an inversion of the above, the diameter being always less than the side.

3. The number of cervical and dorsal vertebræ in this animal appears to be 46; a number almost double that of any recent Saurian animal, and greater than even that of the Ichthyosaurus, which does not seem to possess above 41.

4. They farther differ from both recent and fossil Crocodiles in having the ribs through the greater part of the dorsal series articulated only to the end of the transverse processes; at least, 28 appear to be thus circumstanced; whereas this takes place in the three last

of the Crocodile only; in the other Saurian animals, however, all the ribs are thus borne.

Colonel Birch's specimen exhibits a series of 63 vertebræ; but as they were dug loosely out of the lias marle in which they lay, several appear to be missing, and it comprises only the first 12 of the tail. Mr. De la Beche has a continuous chain of 18 middle dorsal; and, in the late Mr. Calcott's collection, preserved in the city library of Bristol, there is another continuous series of 9, the 8th of which carries the last short rib; this specimen seems fortunately to have succeeded almost immediately to the former.

From these materials we are able to give a tolerably complete account of this part of the skeleton.

Our figures are taken, unless where it is otherwise stated, from Col. Birch's specimen, which being a young animal, has the annular part still separate, the sutures not having yet anchylosed, and on this account exhibits this part of their structure, which we shall designate as the annular suture, more distinctly; but in other points there is no variation in older specimens.

The atlas and axis we have not seen.

The cervical and first dorsal vertebræ appear to have possessed similar forms. The character of these, which extend to the 12th in Col. Birch's series, is represented in fig. 1, 2, 3. plate 41.

They have no transverse processes; the line of suture with the annular part is angular, and they have on either side of the body a double notch, into which appears to have been inserted, by a double stem, a tubercular process corresponding to the inferior tubercle in the cervical and anterior dorsal vertebræ of Crocodiles, and, like it, bearing the false ribs which protected the neck and the first true ribs.

The position of this double notch is near the bottom of the side in the first vertebra, and gradually ascends till it almost rises to, and runs into the annular suture in the 12th. Fig. 1 represents the earliest form; fig. 2. the same, with the tubercular process attached, but from another skeleton; fig. 3. the 12th vertebra; fig. 4. the 13th.

In the course of the succeeding four vertebræ the upper of the two notches runs into and extends the margin of the annular suture; and in the next, (the 18th) the lower notch becomes a distinct tubercle; thus two articulating surfaces are afforded, one on the tubercle, and a second on the cavity formed by the prolongation of the lip of the suture, of which the former must receive the head, and latter the tubercle of the anterior ribs. It will be remembered that a structure exactly similar was pointed out in the cervical and anterior dorsal vertebræ of the Ichthyosaurus; and it corresponds also in some degree, at least, in the office of these parts, with the first dorsal vertebra of the Crocodile, in which the transverse process is not yet fully developed, and remains only a tubercle. Fig. 5 A, and fig. 5 B, represent the 18th vertebra in two points of view.

At length the lower tubercle also disappears, and is swallowed up in a still longer prolongation of the margin of the annular suture; at the same time the stems by which the annular part was attached to the body expand their bases laterally, so as to form incipient transverse processes: these at first point downwards, and are close to the middle of the side, but as they become longer they rapidly ascend and point upwards; this character extends through the middle of the dorsal series; thence they again begin to incline downwards in the posterior dorsals, and in the last, which bears a very short rib, become very much reduced. All the vertebræ from the first developement of the transverse process (27 in number) carry the ribs on a single articulating surface at the end of that process, like the three last dorsals in the Crocodile and the whole series in most other Saurians. The pointing upwards of the transverse processes in the middle of the series seems intended to give a wider sweep to the ribs flanking the thorax and abdomen.

All the changes last described are represented in the accompanying figures, of which fig. 6 represents the form of the vertebræ from the 18th to the 22d, where the margin of the suture forms a remarkably prolonged sinus. Fig 7 A, and fig. 7 B, represent the incipient appearance of the transverse process about the 22d vertebra. The body of this vertebra is shewn first separately, and then with the annular part attached. Fig. 8 shews three vertebræ nearly succeeding this, but from another more perfect and aged specimen. Fig. 9 A, and fig. 9 B, exhibit the middle dorsal vertebræ with and without the annular part, to shew the form of the suture and its different contour from that in the cervical and first dorsal; the posterior dorsals differ only in having the transverse process less elevated, and did not therefore require representation.

The lumbar and caudal vertebræ appear to differ in form from one another only in a less inflection of the lower margin, for the purpose shortly to be mentioned; they are however very distinct from all the others; they have no regular transverse processes, but, instead of them, two separate bones flattened at the extremities, and articulated into a socket near the upper part of the sides of the bodies of the vertebræ; their position is exactly horizontal. We have before observed that the Ichthyosaurus appears to have had similar bones. The lower margin of these vertebræ on the posterior extremity is inflected so as to form two regular indentations, exactly as in the Crocodile, for the reception of the chevron-shaped bone beneath the tail. All these circumstances are represented in fig. 10 A, 10 B, 10 C, which exhibit one of the early caudal vertebræ in three points of view; and fig. 11, which represents one farther in the series, to shew the change in the socket for the articulation of the lateral bones, which is much narrower, and is higher placed.

We have as yet no means of even surmising the number of caudal vertebræ.

The middle dorsals are considerably larger than those of the extremities of the column; the measures of three from different parts of Col. Birch's were:

	Diameter of Articulating Surface.	*Length of Side.*
Cervical	1 inch	$\frac{6}{8}$
Middle Dorsal	$1\frac{1}{2}$	$1\frac{1}{8}$
Caudal	$\frac{7}{8}$	$\frac{5}{8}$

The largest vertebra of Plesiosaurus we have yet seen was $2\frac{1}{2}$ inches in diameter.

On the whole, then, it appears from these remarks, that the vertebral column of the Plesiosaurus recedes from that of the Ichthyosaurus in all the points in which the latter approaches to the fishy structure; that the intervertebral substance must have been disposed much as in the Cetacea, and that on this account, as well as because the annular parts were firmly attached to the bodies, and therefore, by the locking into one another of their articulating processes, must have given a considerable degree of stability to the column, it must have possessed in a much less perfect manner the flexibility which facilitates the peculiar motion of the Ichthyosaurus and of fishes. But it will be presently seen that this was much less necessary to these animals, in as much as the structure of their extremities rendered them much more powerful instruments of progression.

To the description of these extremities we next proceed, premising, that we have never seen the bone which we have called in the

Ichthyosaurus, the furcula or sternal arch, which we yet think it most probable, from the form of the scapula, must have existed in this animal also.

Anterior extremity.[*] It is proper that we should begin by stating, that all the bones composing this part of the skeleton were, in Col. Birch's specimen, loose and detached. The determination of their exact situation may therefore be considered as in a certain degree conjectural; but we trust that the reasons we shall alledge will prove satisfactory, and leave little if any doubt on the subject.

The scapula and humerus represented by *c* and *b*, in the figures of plate 42, have their relations positively determined by a specimen in the Bristol library collection, in which they occur together. This also shews the form of the latter bone more completely, which in Col. Birch's collection is much compressed. The scapula, *c*, is still smaller than in the Crocodile, but generally resembles it in form; its back is slightly excavated, which gives it a figure proper for attachment, as in the Ichthyosaurus, to the sternal arch; its upper extremity also forms a concave triangular articulating face, which probably received a process from the sternal arch.

The humerus, *b*, requires no description; it could only be confounded with the femur, and its association with the scapula removes this suspicion.

The flat clavicles, *a*, *a*, are so exactly similar to those of the Ichthyosaurus, that no one familiar with the latter bones could hesitate in assigning their place. Their articulating surfaces moreover (although much compressed in Col. Birch's specimen), clearly coincide with those of the scapula, in forming the glenoidal cavity;

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[*] If we follow the views suggested by the late observations on the muscles attached to the analogous bones in birds and reptiles, we must here, as in the Ichthyosaurus, consider what has been termed in the text the clavicle as rather answering to the coracoid process.

more especially is this coincidence visible in the scapula which has a narrowed articulating face towards the clavicle, and a broader towards the humerus. The whole evidence then stands thus: some bone having a certain articulating surface was requisite to complete, together with the scapula, the glenoidal cavity; these bones exactly possess the requisite form; they agree exactly with the bones holding the same place in the Ichthyosaurus; and there is no other place in the skeleton which they can be supposed to have occupied, except perhaps that of ossa ilia, with which however they will not be found, on careful examination, at all to agree.

The bones *d*, *d*, we have assigned to the office of radius and ulna, because their articulating surfaces at the one end agree with those of the humerus, and at the other with those of the three which obviously form the carpal series in the paddle, and because we cannot discern any other equally probable place in the arrangement of the skeleton.

Of the paddle, the three first or carpal bones marked *e*, *e*, *e*, are well characterised; of these the central has a form not unlike that of the phalanges of reptiles, but more flattened; and with articulating extremities, forming a smooth and gentle curve; the exterior bones have a general texture like that in the paddle bones of the Ichthyosaurus, but have a reniform outline, and are much flattened.

Of the succeeding bones of the paddle, Col. Birch's specimen exhibits two fragments; one (fig. 1, plate 42) exhibiting three rows of phalangic bones, to which the description already given of the central carpal bone would equally apply, and which (except that they are shorter) closely resemble those of the sea turtle, mingled with bones exactly resembling the round bones, which form the external series in the paddle of the Ichthyosaurus. The other specimen (fig. 2) exhibits these phalangic bones in a longitudinal series, containing traces of at least eleven rows counting lengthwise. From these specimens we may draw the following conclusions:

1st. That the series of small bones forming the paddle was very numerous, approaching in this respect to the structure of the analogous part of the Ichthyosaurus; and secondly, that there were a series of round bones like those which form the external bones of the Ichthyosaurian paddle, and probably holding a like place; for some of those in fig. 1 have a lateral situation (which would be required in this conformation).

Thus, therefore, a general similiarity of organisation between this important member in the Plesiosaurus and Ichthyosaurus appears to be established. On the other hand, a comparison with the paddles of the sea turtle will exhibit such fresh analogies as to indicate that in respect of the various forms of animal extremities, the Plesiosaurus holds as it were a middle place between it and the Ichthyosaurus; for we may remark in the first carpal series of the turtle three bones not unlike those of the Plesiosaurus; these are succeeded by two rows exactly corresponding, as we have before observed, to those holding a similar place in the Ichthyosaurus. The corresponding bones in the Plesiosaurus we have not yet seen (unless indeed those of a rounded form not placed laterally, and therefore forming the exterior series, but at the end of fig. 1, may be accounted such); but the double analogies above stated scarcely leave a doubt that they likewise had a similar form. The succeeding and phalangic series in the turtle exactly agree with those of the Plesiosaurus in form, excepting that they are individually longer, and, as in quadrupeds, exhibit only a few joints, whereas in the Plesiosaurus the comparative shortness of the individual joints is much more than compensated by their exceedingly greater number, and a much greater flexibility is thus imparted to the whole paddle.

Here then we may trace a series of links between the extremities of land and sea animals. The sea turtle will form the first term of these, in which the arrangement and form of the carpal, metacarpal, and phalangic bones, will be found to differ from other quadrupeds, and approach to the Plesiosaurus in many points, while yet their number and general appearance more nearly resemble the usual quadrupedal type. In the Plesiosaurus these peculiarities have added to them that of a much greater number of joints, and an external series of rounded bones. In the Ichthyosaurus the usual phalangic form is completely abandoned, and all the bones become irregular polygons or trapezoids, thus admitting a still greater number of separate joints into the same space, and proportionally encreasing the flexibility. In the fins of regular fishes, flexibility is also the object apparently aimed at, and produced by the number of joints and their cartilaginous substance, but their form more nearly resembles that of ordinary phalanges. We have ventured to add a figure of the paddle of the Plesiosaurus, as conjecturally restored from the two fragments, and the analogies alluded to, fig. 5, plate 42.

The general arrangement of the whole extremity is also important, as exhibiting a similar gradation of arrangement; for with the flat clavicular bones of the Ichthyosaurus, and with the intermediate species of paddle above described, we find the distinct form of humerus, radius, and ulna, belonging to quadrupeds generally.

Of the posterior extremities, we have seen some imperfect bones of the pelvis and femora; but we postpone any attempt to describe this part of the animal, till future opportunities shall have provided us with more illustrative specimens.

Geological Seat of the Remains of the Plesiosaurus, and other Saurian Remains found in this Island.

We are as yet acquainted with no instance of the occurrence of the remains of the Plesiosaurus in any other formation than the lias, where they have been found in Dorsetshire, Somersetshire, Gloucestershire, and Leicestershire, in the same localities with those of the Ichthyosaurus.

In conclusion, we shall submit, in order to attract more general notice to the enquiry, a short list of the other varieties of Saurian animals, which, as far as our knowledge extends, have been found in a fossil state in this island.

We have never seen any genuine remains of the crocodile in the lias of the southern counties; those which have been usually considered as such really belonging to the Plesiosaurus. This also is the case with the specimen discovered by Stukely at Newark in Nottinghamshire, and described in the Philosophical Transactions, which, from the imperfection of the plate there given, M. Cuvier was led to consider as a crocodile. We have not however, as yet, had an opportunity of examining the bones from Whitby.

Remains of an undoubted species of crocodile, somewhat resembling the Gavial, have been found in the upper beds of the great oolite, or in the Cornbrash, for the distinction between these beds cannot in that part of the country be ascertained, at Gibraltar, eight miles north of Oxford, on the river Cherwell; the vertebræ of this variety agree with the second species from Honfleur, described by M. Cuvier, in having both faces of the vertebræ slightly concave like the Plesiosaurus; but their proportions, articulating surfaces for the ribs, &c. agree closely with the crocodile, as does the head, which has also been found.

Another head, but apparently of a different species, has been found in the Portland limestone in the Isle of Purbeck, and is now in the possession of Mr. Johnson of Clifton.

An immense Saurian animal, approaching to the characters of the Monitor, but which, from the proportions of many of the specimens, cannot have been less than forty feet long, occurs in the great oolite at Stonesfield, near Oxford. Professors Kidd and Buckland have been long engaged in the study of these interesting remains, and it is hoped may soon communicate the result of their observations to the public. Vertebræ and phalanges of another animal, apparently allied to the Enalio-Sauri described in this paper, but clearly of a distinct genus, occur in the Kimmeridge clay in the pits at the foot of Shotover hill near Oxford.*

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* In Whitehurst's Theory of the Earth, p. 184, it is mentioned that the impression of a crocodile was found at Ashford, in the first bed of the mountain limestone of Derbyshire, by Mr. Henry Watson of Bakewell. As this is very important in indicating the traces of these animals in an older formation than those above mentioned, and one indeed in which the very existence of Vertebral animals has been denied, (although certainly only in consequence of a very partial acquaintance with the organic remains it affords, among which the palatal tritores of fishes, the incisores of the shark, and the radii of Balistæ, are not very uncommon), it is very desirable to obtain further information concerning this specimen, if it be yet in existence, and particularly (since the term Crocodile has often been very vaguely applied) a precise account of its specific characters. With the view of leading to such a result, we have added this note.

The following article, extracted from the prospectus of Mr. Mantells' expected work on the Geology and Fossils of Sussex, contains another interesting notice connected with this subject. "41 Lower jaw of an animal of the Lizard tribe, in chalk, containing twelve teeth. Two Vertebræ in chalk, of the celebrated fossil animal of Maestricht." I am also indebted to him for the following communication on this subject.

In the limestone of the Oak Tree Clay, or Weald Clay of Sussex, numerous remains occur of an animal of the Lizard tribe. Fragments of the ribs, clavicle, radius, pubis ilium, femur, tibia, metatarsal bones, vertebræ, and teeth, have been discovered; and although the specimens are, for the most part, exceedingly mutilated, yet the structure of the original animal is very clearly indicated. From an attentive examination of these remains, there can be no hesitation in considering them as belonging to the same un-

P. S. While this paper was passing through the press, the author has received a communication from a friend resident in Paris, in which it is stated, that the discovery of the composition of the lower jaw of the Ichthyosaurus in a manner analogous to that of the animals of the Saurian family, had been anticipated by Mr. Cuvier, and communicated in the autumn of 1820 to Messrs. Leach and Clift, although it appears that the general fact only had been observed, and that the details of the structure of this part had not been fully examined.

The author is happy to have an opportunity of making this acknowledgment; he was entirely ignorant of this anticipation until his own observations had been committed to the press.

known species of Crocodile, as the osseous remains discovered at Honfleur and Hâvre, with which they also accord in their mode of petrifaction, and in the nature of the stratum in which they are entombed. Vide Cuvier, Animaux Fossiles, Tom. IV. p. 17, 18.

Crocodiles.

Tab. XXXIII.—All the specimens delineated in this plate are from the upper chalk.
Fig. 1. Conical striated tooth. Mr. König supposes it to belong to the Ichthyosaurus, others that it resembles the incisor teeth of Anarrhicus lupus.
Fig. 10. Vertebræ of the Ichthyosaurus?
Fig. 13. Certainly the vertebræ of a species of Crocodile.
Tab. XXXIX.—Dorsal fin of a fish of the genus Balistes? in chalk.
Tab. XLI.—Fig. 1. "Very like in miniature the large amphibious animal of Mæstricht in our Museum: I should not hesitate to consider it as a species of lacerta."—Mr. König.
Fig. 2. Front view of the two anterior teeth. I do not think that this specimen may not have been the jaw of a fish.
Fig. 3. Two vertebræ of the celebrated animal of St. Peter's mountain: these certainly resemble the specimens in the British Museum, and also those figured by Faujas St. Fond.
Tab. XLII.—The whole of the specimens figured in this plate were discovered in one block of chalk. The remains of an unknown fish? some say Lacerta?

On the same authority it is suggested that the humero-sternal part of the Ichthyosaurus and Plesiosaurus, viz. the furcula, coracoid processes, &c. bear a greater analogy to the Monitor Iguana, and others of the Lacertæ than to the Crocodile. The present writer however is still inclined, from the comparison of the osteology of the head, to approximate the Ichthyosaurus rather to the latter than the former.

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Since the completion of the press, I have received from Mr. De la Beche the following particulars of a specimen of Ichthyosaurus lately discovered at Lyme, which I am anxious to subjoin, as they shew the total number of vertebræ and ribs in this animal.

'The specimen (I. communis) lately found, is very interesting; it consists of the head, with all, or nearly all, the vertebræ *in place*, with the exception of two. The total number of vertebræ amounts to 104, not including the atlas and axis, which are also *in place*; diameter of the largest dorsal vertebræ 1⅛ inch. This specimen contains 31 ribs on each side, which I take to be the real number of ribs that the Ichthyosaurus possessed, as none appear to be wanting; length of the largest rib 11½ inches; the lower jaw 1 foot 6½ inches long, is in tolerable condition; the other bones of the head, with the exception of the maxillary and intermaxillary bones, are much crushed. The chevron bones come in beautifully after the ribs cease. The vertebral column increases (as in the Proteosaurus) from the atlas and axis to the middle dorsal, and then decreases to the extremity of the tail. There are traces of the pelvis in this specimen; it must have been very simple, as after a careful examination I could not detect any difference in the vertebræ about the place where it ought to be attached.

XXXI.—*Extracts from the Minute Book of the Geological Society.*

1809, *April* 7.

A notice respecting the Mucrus Mine, Killarney, by Mr. Wright, communicated by Dr. Babington, was read.

The Mucrus Mine was worked for about five years (from 1749 to 1754) to great advantage; the depth was then thirty-six fathoms, but the part of the vein within reach of the first shaft having become too narrow to pay for the expense of a second, it was determined to sink some distance to the east in the direction of the vein, which was thus recovered at the depth of from seventeen to twenty fathoms. It yielded yellow copper ore, and was five feet wide; the ore however being too sulphureous it was abandoned, though the original shaft had brought in £30,000, and was so easily drained that a common windlass kept it dry. The cobalt being totally unknown, except to a single adventurer (who on one occasion took away about twenty tons) was neglected, and landed only as rubbish, till a more experienced miner, since dead, at last pointed out its nature and value. From that time people visiting the mine have carried off specimen after specimen, so that the original profusion would now be doubtful, were not these circumstances recollected by most persons then resident in the neighbourhood. The ore has a granulated and metallic appearance; it has the hardness of stone; its colour is dark blue, tending to a beautiful pink. A mass of about a quarter of a hundred weight had the appearance of being found within the copper of the vein; but this was only conjecture, for in whatever quantity it might then have been encountered, it was avoided as much as possible, and the many tons landed were removed as rubbish to make way for the miners. One great cause of the abandonment of the mine was the pecuniary difficulty occasioned by the war. Commercial intercourse, particularly the high insurance to Bristol, was too expensive for the then state of the mine, viz. working upon a new and shallow part of the vein. Since that period lands having risen much in value, the proprietors have been unwilling to injure the surface of their grounds by the admission of workmen who might trespass upon and disfigure their estates. The mine in question is on the demesne of Mr. Herbert, and is one of the most picturesque spots about the celebrated lake of Killarney. It is situated at the head of the Great Lake, which, being thirty-seven fathoms deep, is navigable for boats of any burthen for five miles to the head of the river Laun, a considerable stream, as broad as the Thames at Windsor; this is also navigable, though not to any useful extent, nor at all times, owing to some shallows which might easily be deepened. The fall in the ten miles to the sea is only thirty-seven feet. Castlemain Bay, the port, is a safe harbour, though there is a bar at the entrance of it. This natural navigation might be improved at no great expense, and it is so desirable for the commercial and agricultural purposes of the inhabitants of a district not only extensive, but valuable for its oak woods as well as its mines, that it has become a national object to clear the bed of the river, and the Government having offered to defray one-third of the expense, the landed proprietors and others have agreed to raise subscriptions sufficient to carry it into execution, so that the business only requires to be set about.

The copper mine of Ross Island, in the neighbourhood of Mucrus, has revived the business of mining, in which the peasantry were formerly employed so effectually, that miners may be procured in plenty on the spot, while the local advantages of cheap and abundant markets, inexhaustible fisheries, and a low price of labour, are in that part of the kingdom peculiarly great.

Mr. Herbert made one trial only without any previous boring, and found a thin sheet of stone coal at four fathoms depth, and for the most part slate hardening into rock over the coal, so as to afford a very safe roof. The road thence to the head of water at Buleragh, or as it is better known by the name of Cloghareen, has a regular descent, except a quarter of a mile up hill; whilst the source of water at Cloghareen, formerly employed to turn tilt-hammers, water-blasts, &c. is perpetual, and uninfluenced by any season.

The high mountains south-west of the mines are a brown, tending to blue slaty rock very dense, where cut deeply by torrents. These mountains are evidently imposed on a foundation of limestone of so fine a grain as to take a polish, and afford marbles of a great variety of colours; red and white, and green and white, are the predominant. The lake is the boundary of the two substances. The gentle ascents and bases of all the mountains, as well as the plains on every side of the mountains, are of the same limestone bursting out even at twelve miles south at the sea; but in some places varying in the level from horizontal to a dip of about 30°, so that there must be fractures or faults in it. This limestone is the metallic bed at Ross Mine and at Mucrus; the coal is found in the slate hills, and imposed also on the limestone.

The vein of Mucrus has been held in high estimation in every age of which tradition has preserved any accounts. Rude and laborious traces of ancient minings remain in several places, and are vulgarly, though erroneously, known by the name of Danish works. Many shafts at several miles distance have been sunk, though long since filled up, of which no history gives us any relation.

Ross vein lies parallel to Mucrus vein, at the distance of one mile and a half, and in the same bed of limestone. East of Ross Island, at Mr. Richard Herbert's, of Capirnaane, a trial has been made, and lead found (probably in Ross vein.) Lead or copper is also said to have been met with in a small island, lying midway between Capirnaane and Ross, but little is known respecting it.

There is a house remaining at the new shaft, formerly used as an assaying furnace or office.

Six years ago the new shaft remained open, and it may now be cleared at a small expense, being still dry.

The late Mr. Herbert, who had very considerable knowledge of chemistry and metallurgy, expressed his opinion in the year 1756, that if copper gave £60 per ton, the ore of the new shaft would be worth working.

1814, *May* 20.

Notes concerning the Geology of part of North America, lying to the west of Hudson's Bay, extracted from various papers presented to the Society by Earl Selkirk.

The following geological observations upon a part of the territory of the Hudson's Bay Company were transmitted to the Geological Society, by their late member, the Right Hon. Earl Selkirk. His lordship having at the same time presented the Society with a collection of specimens from the rocks referred to in these observations, the descriptions of all the rocks, of which specimens have been received, have been corrected by an examination of the specimens themselves.

The notes concerning the rocks found on the banks of the Nelson river are extracted from the journal of Mr. W. Auld, an officer of the Hudson's Bay Company, appointed to survey the lower part of that river from York fort to Split lake. A few specimens from the same river below Split lake were obtained from Mr. Kerney, a gentleman who after visiting an Indian village on the Missouri, about the latitude 47° and longitude 101°, descended the river Nelson from lake Winipic to York fort. A description of the few specimens which he collected on the river Nelson will be appended to the notes of Mr. Auld.

The observations on the route from York fort to Winipic, and thence to the Red river, were made by Mr. Abel Edwards, Surgeon to the Settlement on the Red river; and it is by this gentleman, and in the course of the route which he pursued, that the specimens transmitted to the Society were chiefly collected. The specimens from No. 14 to No. 27, both inclusive, were collected by Mr. Holdsworth, surgeon at York fort, and by him together with the observations that accompany them, transmitted through Mr. Edwards to Lord Selkirk.

Notes upon Nelson River, near York Fort, Hudson's Bay, extracted from the journal of a survey made by Mr. W. Auld, July, 1812.

The high banks begin near the mouth of the Nelson river, about seven miles below Flamborough Head, being at the head about 100 feet high. They are of a light clay-colour, composed of mud and sand with a few small stones, and are of a very firm consistence, presenting every where a steep ascent, except where water has undermined them. Where this has happened, portions of the cliff have slipped down; and these are soon swept away by the strong current of the river. Opposite to the Seal Islands, the bank cannot be less than 150 feet high. Here there appears to have been at some former time an extensive slip. The fallen mass is about twenty or thirty yards wide, and two or three hundred yards long, and when I observed it, was about 10 or 12 feet higher than the river, which was then much above its ordinary level. Timber grew upon this under-cliff to a pretty good size, as the earth on its surface was deeper than upon the summit of the bank, where the layer of vegetable mould was very thin.

Near the first rapid as you ascend the river the acclivity of the bank is about 60°; in many places the ascent is almost perpendicular; an instance of very great tenacity and consistence in a body containing a large proportion of sand with scarcely any mud. The substance of the bank, when consisting almost entirely of clay, not unfrequently assumes the appearance of stone, having the form of regular lumps, which resemble limestone. These lumps break under pressure, but in breaking preserve an angular shape, the surfaces of the fracture resembling those of limestone. Limestone is found a few feet below the clay at the bottom of the bank and in the bed of the river.

At the second rapid as you ascend the river, the portage is good, being about 100 yards in length, over flat limestone rocks, which are not more than four or five feet above the level of the water. From the head of this rapid the distance is two miles to the foot of the great limestone fall.

At the great limestone fall, the river, which is here nearly a mile broad, does not fall suddenly, but rushes with inconceivable impetuosity over the beds of limestone. We had here an opportunity, in walking over the surface of the ice, to notice the tremendous height to which the water had risen during the spring floods at these rapids, trees of various sizes lying broken down by the ice at the height of at least forty feet above the level of the river, as it stood where we observed it. There being but little depth of water in any part of the river's passage over the flat beds of limestone, these on the breaking up of the river obstruct the passage of the ice from bank to bank; which being thus collected in large masses, dams the water up. When the ice gives way, the water instantly subsides, leaving the banks covered with a thick wall of ice, which it requires the greater part of the summer to dissolve.

Eight miles above the limestone fall is a portage forty yards in length, over flat rocks of a very solid and hard texture, of a greyish brown colour. This rock now forms the bed of the river, and we no longer observe the slightest trace of limestone among the boulder-stones along the shore. Below the portage the limestone rises to the height of about ten or twelve feet above the level of the river, and consists of plates that are from two to twenty inches thick.*

As we ascend, the bank contains more sand and gravel with a larger proportion of boulder-stones, rising to the height of about one hundred feet. Near the water, the clay assumes the appearance of angular masses of stone, whose surfaces appear to be washed with a red ochry matter.

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* The specimens No. 17717 and 17718, Coll. Geol. Soc. brought by Mr. Kerney from this part of Nelson river, consist of black flint, much resembling the flint obtained from our chalk pits.

"The same kind of limestone," observes Mr. Auld, "is also found in Churchill river, at the distance of about fifty-six miles from the sea, extending along that river more than twenty-five miles, and rising at last for twelve miles together to the height of sixty or seventy feet above the water, while the bed of the river is composed of the same hard brown rock that we find in Nelson river. The same limestone is also found in that branch of Hayes's river which is called the Shemataway, where it is of great height, and is covered as in Churchill river, with only a thin coating of soil. It is seen again in various places upon Severn river, being first observed at the distance of about thirty miles from the sea, and extending throughout the distance of above fifty more, but in no place rising more than fifteen or eighteen feet above the water. The natives say that the same kind of stone appears in the rivers between the Albany and the Severn. At Martin's fall, upon Albany river, below Gloucester house, the same rock is said to be found not in strata but in mass, and to be a white one, much lighter in colour than the stratified rock upon the Shemataway. Upon the Seal river, which I ascended eighteen years ago, I only remember that the banks adjoining two rapids were composed of laminated stone."

At the Kettle falls, the country rises to a less considerable height above the river. The bank is now about twenty-five feet high and very sloping. The river here runs through numberless chasms formed by a multitude of rocky islands, of which the greater part are perfectly bare of vegetation, though some are covered to the top with herbage, and two or three have large trees growing in perfection upon them.* Presently afterwards the channel being narrowed suddenly, to the width of one hundred yards, a prodigious rush of water forces itself through a horrid opening in the rocks.

The portages at the Kettle falls amount together in a direct line to one-third of a mile. At the second portage we carried every thing one hundred and eighty-two yards upon the north side of an island, where numerous excavations of a circular form are seen in the solid rock. It is from the form of these excavations that the Kettle falls have received their name. The origin of these excavations may probably be traced to boulder-stones, which lodged in cavities, set in motion by the water, and aided by the attrition of sand, wear themselves thin hollow cups in the rock. The rocks upon this island consist of whinstone or granite.

Towards the upper portage the ground rises to the height of one hundred feet above the river, and is remarkably steep to the distance of one-third of a mile above the portage.

On our return, when about the middle of the river, below the great limestone fall, we observed a dry shoal two or three hundred yards long, composed of many hundred blocks of limestone each weighing several tons, and four feet thick or upwards, resting upon stones of a smaller size. This shoal, never having been observed before, must have been formed during the deluge of ice in the spring. It is not impossible that the next spring will entirely remove it.

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* No. 17719, Coll. Geol. Soc. brought by Mr. Kerney, from this part of the river, consists of hornblende slate.

Notes taken during the summer of 1812, *on a journey from York Fort Hudson's Bay, to Lake Winipic and the Red River, by Mr. Abel Edwards, surgeon at the settlement on Red River; together with a description of the specimens collected by Mr. Edwards and by Mr. Holdsworth, surgeon at York Fort.*

Hayes's River. The current uniform, compared with that of most of the other rivers between York fort and Lake Winipic. The bed stony.* The shores on both sides bold and low alternately. The soil loose and argillaceous; but in some places sandy.

Steel River. At its entrance into Hayes's river very narrow, but soon becoming wider. The colour of the water whitish, forming a striking contrast with the colour of the water of Hayes's river. The current more uniform than that of Hayes's river. The bed stony. The greatest depth of water nine feet. The shores similar in appearance to those of Hayes's river, but the soil rather more sandy.

Hill River. The current strong and interrupted. The bed stony. The shores resembling those of the two former rivers, except that where the banks are high, they are more sloped. At the first carrying place the descent of water is about eight feet perpendicular. The portage is over a bed of granite intersected by large veins of quartz running east and west.

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* From Mr. Auld's observations, it seems probable that limestone forms the stony bed of this river

Specimens collected upon Hill river.

No. 17720, Coll. Geol. Soc. from the second bank on the north side of Hill river, as you ascend from Hill river house. Red calcareous clay.

No. 17721, from the Sugar loaf. Slaty calcareous clay, enclosing many fragments of limestone, and having a tendency to break into rhomboidal forms. The strata of this clay rise towards the west at an angle of 80°. All the banks of the river from its mouth to the Sugar loaf are composed of it.

No. 17722, from the 1st. carrying place. Slaty granite, or gneiss, composed of white quartz, black mica, and flesh-coloured felspar.

No. 17723, From the same place; and forming veins in No. 1. White milky quartz, containing yellow iron pyrites.

No. 17724, from the same place. A slaty rock, consisting of quartz and mica, without any felspar.

No. 17725, from the Point-of-rock handing place. Resembles No. 4.

No. 17726, from the rocky carrying place. Black slaty hornblende rock, the hornblende being in small crystals.

No. 17727, from little rocky island. Green talc imbedded in granite.

No. 17728, from the smooth rock carrying place. Felspar forming veins.

No. 17729, from the same place. Black mica and felspar, forming veins in a small grained granite.*

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* The following specimens collected by Mr. Holdsworth, or from rivers not mentioned in the route of Mr. Edwards.

No. 17730, from the lower carrying place in Jack river. Coarse grained granite, containing reddish felspar and black mica.

No. 17731, from the upper carrying place in Jack river. Granular quartz rock, containing black foliated mica, No. 17732.

Swampy Lake. Length ten computed miles. At its entrance it is very shallow, owing to a sandy bar, which separates it from Hill river. On crossing the bar you immediately get into water from one to five fathoms deep.

Holy Lake. Length thirty miles, greatest breadth four miles. Depth of water from three to four fathoms. Colour of the water whitish. Bottom sandy. In this lake are several small islands, mostly rocky.

No. 17739, from the northern side of Holy Lake, near Oxford House. Compact dark green chlorite slate.

Wippinapanish River. Course very winding. The shores more flat and rocky than those of the rivers to the east of the Holy Lake. The bed stony.

Plentiful Lake. This is a very small lake being only four miles long, and scarcely two broad.

Rabbit River. Current easy. Shores low and grassy. The bed muddy.

Side Pine Water. Extends from the Rabbit river to the Hill carrying place. Colour of the water black. The bed rocky. The coast towards the carrying place is precipitous, and composed entirely of rock.

No. 17740, from the Hill carrying place. Compact fine grained hornblende rock. A large dyke was observed at the hill

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No. 17732, from the east end of Knee lake, ten miles from the entrance. Resembles potstone, but is harder and is fissile.

No. 17734, from a small island at the Knee. Oxidulous iron. The compass does not traverse on passing this island.

No. 17735, from a small island one mile beyond the Knee. Chlorite slate.

No. 17736, from the second carrying place in Trout river. Fine grained mica slate, with protuberances arising from some imbedded crystals.

No. 17737, from the Whitefall carrying place. Granite.

No. 17738, from the same place. Pinkish-coloured hornstone, with appearances of slate on the margin of the specimen.

carrying place running in a perpendicular direction, and crossed by another that ran horizontally about three inches above the level of the water. Besides the dyke there were several veins, of which the largest ran south-west and north-east. Several loose stones were found here resembling No. 17722.

The places from which the two following specimens were brought are not mentioned in the route, but it is presumed that they lie near to the Hill-carrying-place.

No. 17741, from the painted stone carrying place. Greenish quartz rock. The portage is over a rock resembling No. 17722.

No. 17742, from the portage in Sea river. Gneiss with white and flesh coloured felspar.

Ecchemamis, or Little River. Very narrow and winding, and extremely shallow, containing many Beaver dams. Shores flat, resembling water meadows. The bed muddy.

Henry Lake. Length four miles, breadth one mile, water blackish and very shallow. Bottom muddy.

Playgreen Lake. This is a continuation of the great lake Winipic; and is full of islands and low rocks; greatest depth of water ten feet. The bottom muddy.

Lake Winipic. On the 14th of August, our boats entered this lake. From the first point on the western side to the first point on the eastern side, bearing south-south-east from the former, the depth of water was uniformly from three to three and a half fathoms. On the 19th of August, in going from the point above Beaver river to Blood river, we sounded with nine fathoms of line, and did not find the bottom. The water of the lake is of a whitish hue, and the bottom is composed of a mixture of sand and mud. The coast on the eastern side, until you arrive at the straits, is low and sandy; but numerous rocks lie concealed at a little distance from the land, and in many places breakers were observed to a great distance from the shore. In the strait the coasts on both sides are bold and rocky, and on the eastern coast there are numerous harbours. On the 21st of August, my lead being stolen out of the boat by some Indians, I was unable to take any more soundings.

Specimens collected upon Lake Winipic.

No. 17743, from a small rocky isle north of Blood river. Large grained granite, composed of white quartz, flesh coloured felspar and black mica. This granite is composed of larger grains than any that we found in the rivers below. It had numerous veins of quartz ramifying through it in various directions, though mostly running from north to south.

No. 17744, from the west side of the lake near Buffalo island. A greyish fine-grained rock, consisting of quartz and mica, with some carbonate of lime. The veins in this rock were large and numerous, running north-east and south-west.

Red River. On the 29th of August, our boats entered the Red river, by the largest branch, the mouth of which is narrow, and the banks on both sides of which are low and marshy, to the distance of about nine miles from the lake. The face of the country then changes, and the shores become more bold. The bed of the river is composed entirely of mud. The colour of the water is white.

The appearance of the country in the vicinity of Pembina river, is quite flat, with little wood. Vast plains extend in every direction, having nearly a level surface.

A single specimen, No. 17745, brought by Mr. Kerney from the banks of the Missouri, at the latitude and longitude above mentioned, consists of a blue compact porcellanic limestone. "There is reason to believe," observes Lord Selkirk, "that limestone extends through all the country west of Lake Winipic as far as the rocky mountains, and that there the primitive rocks reappear. On the verge of these mountains coal has been observed; but their central parts are described as being composed of very hard rock, whose beds are vertical or highly inclined. Some specimens collected in those mountains were sent home in the year 1811, and fell into the hands of Professor Jameson of Edinburgh."

1815, Nov. 17.

An extract of a letter from Mr. J. Templeton, of Belfast, addressed to J. J. Berger, M. D. on the formation of peat bogs, was read.

" Your request about the plants of bogs and of their formation, I will endeavour to answer as fully as possible. My theory is, that no bog is ever formed without an abundant stock of moisture. The greatest mass of bog almost uniformly derives its origin from impediments intercepting the flow of water from a valley; a lake is thus formed; in whose waters is only nourished if in the mountain regions, the Lobelia dortmanna, and sometimes the Sparganium natans with a few straggling stunted plants of Scirpus lacustris. If in the lowlands a greater variety appear, we may observe the curious " Conferva echinulata," floating like powdered verdigris; immersed at even great depths grow Sponges, the Charæ, the Ceratophylli with numerous Confervæ, and around the shores gradually approaching the centre; as their annual decay lessens the depth of water, we find various species of Potamogeton, the Nymphæa alba, N. lutea, the Lobelia dortmanna (if the shore is composed of sand or small gravel) Polygonum amphibium, Sparganium natans, Scirpus lacustris, Arundo phragmites, Typha latifolia, Schœnus mariscus, Menyanthes bisfoliata, Alisma plantago, Phellandisum aquaticum, Sparganium simplex, S. ramosum, Cicuta virosa, Sium latifolium, S. nodiflorum, Butomus umbellatus, Sisymbrium nasturtium, S. amphibium, Œnanthe crocata, Œ. fistulosa, Scirpus palustris, S. fluitans, Stottonia palustris, Hydrocharis morsus ranæ, Sagittaria sagittifolia, Ranunculus aquatilis, R. fluviatilis, R. hederaceus, Carex paludosa, C. ampullacea, C. acuta; R. aquaticus; To these plants succeed those which require to have themselves altogether uncovered with the water, or their roots fixed in a watery or soft mud, as the Sphagnum latifolium, S. cuspidatum, S. capillifolium, S. squarrosum; Dicranum glaucum, D. flexuosum, Hypnum cuspidatum, H. stellatum, H. nigrosum, H. scorpioides. H. revolvens, H. aduncum, H. palustre; Polytrichum commune; among these mosses grow Vaccinium oxycoccos, Andromeda polifolia, Drosera longifolia, D. anglica, D. rotundifolia, Schœnus albus, Scirpus multicaulis, S. cœspitosus, Eriophorum angustifolium, E. vaginatum, Narthicia ossifraga, Erica tetralix; when the bog rises higher, and is somewhat drier, Erica vulgaris, E. cinerea Myrica gale, Vaccinium myrtillus, Empetrum nigrum appear (especially on high or rising grounds) with Eriophorum vaginatum, Nardus striceta, Agrostis alba, A. vulgaris, Melica cærulea, Montia fontana, Vaccinium vitis idæa, Menzieria polifolia (Erica Daboocia) Pyrola media, P. minor, Juniperus communis, J. procumbens, Ulex nanus, Salix prostrata, S. fusca, S. repens, S. argentea, Carex pilulifera, C. binervis, C. recurva; and united with these in great quantities, Trichostomum lanuginosum, Dicranum flexuosum, Polytrichum commune, Bartramia arcuata, Hypnum splendens, H. loreum, H. cupressiforme and H. molluscum. When these plants vegetate luxuriantly, the bog rises rapidly, and the formation of the best kind of peat is accomplished, very different in consistence from that formed by the deposit of the mere aquatics, which partake of a clayey or saponaceous texture, and although they give a strong heat they do not kindle so freely as this more spongy kind. The following plants occupy our moist grounds, but can scarcely be said to administer to the formation of bog; Pinguicula vulgaris, Triglochin palustra, Schœnus nigricans, Mentha aquatica, M. hirsuta, Lycopus Europœus, Centunculus minimus, Iris pseudo acorus, Gallium uliginosum, G. palustre, Rumex aquaticus, R. acutus, Myosotis palustris, Parnassia palustris, Anagallis tenella, Hydrocotyle vulgaris, Juncus effusus, J. buffonius, J. conglomeratus, J. lampocarpus, J. acutiflorus, Alisma ranunculoides, Polygonum amphibium, P. hydropiper, P. minus, Stellaria uliginosa, Comarum palustre, Ranunculus flammula, R. lingua, Sium verticillatum, Scrophularia aquatica, Sisymbrium sylvestre, Hypericum elodes, Carex riparia, C. cæspitosa, C. vesicaria, C. davalliana, C. pulicaris, C. stellulata, C. curta, C. divisa, C. muricata, C. paniculata, C. œderia, C. flava, C. pilosa; Scutellaria galericulata, Pedicularis palustris, Viola palustris, Malaxis paludosa, Orchis latifolia, Carduus palustris, Gnaphalium uliginosum, Senecio aquaticus.

I conceive that the peat or mossy stratum formed on the tops of mountains is nourished by the mists condensed on their tops; and that the bogs in a valley not immediately produced around or by a lake, are formed in the first place by musci intercepting the flow of water from a spring, and generating that spongy soil on which the second class of plants grow; this kind of bog in many of our valleys may be seen to rise considerably higher in the middle than when the water is allowed to percolate more freely through the substance, and flow off whenever drains are cut into this bog, when its increase is stopped and a very great depression mostly takes place. The surface is then apparently converted into a soil fit for the husbandman to begin to work upon; but all those who have speculated on this soil, have soon found that without great expense for manure the productiveness soon failed and disappointed their hopes."

1816, *June* 21.

A notice respecting the discovery of some fossil bones was read. It was contained in a letter from Robert Anstice, Esq. M.G.S. of Bridgewater in the county of Somerset, addressed to the late Francis Horner, Esq. M.P.

1. Bones (belonging apparently to the great animal discovered at Lyme) have been found in a quarry of lias, at the distance of a quarter of a mile E.N.E. of Kingsdon, between Somerton and Ilchester, in the county of Somerset.

2. A molar tooth of an elephant, and some large bones, have been found in an alluvial soil adjoining the bridge over the river Yeo, at Yeovil, in the same county.

3. A fish, which appears to belong to the genus Clupia, and resembling Clupia alosa, has been found in lias at East Quantockhead, about 18 feet under ground, above high water mark.

4. Teeth of some unknown carnivorous animal have been found in the water course of a peat moor, in the parish of Calcott, between Bridgewater and Glastonbury.

1816, *Nov.* 15.

A notice from James Sowerby, Esq. M.G.S. on fossil organic remains found on the bank of the Tagus near Lisbon, was read.

These remains are, an Ostrea similar to the O. virginea Linn. a Mactra, the cast of a large Serpula, and other shells which bear a great resemblance to those found in the Calcaire grossière of the basin of Paris.

1817, *April* 18.

A letter was read, from Dr. Meade to Mr. Vaughan, relating to a slab of serpentine from North America.

The quarry whence the slab was obtained was situated near the town of Milford, in Connecticut. It is a serpentine rock. The whole country in the neighbourhood is of a primitive formation, consisting principally of gneiss and granite alternating with primitive limestone. A stratum of the serpentine, several yards wide, runs between the limestone. It extends for several miles, accompanied with asbestos, amianthus, and diallage. The quarry is extensively worked.

The serpentine has considerable resemblance to the vert antique; the green parts, which are the most abundant, are of serpentine. Veins of white calcareous spar run through it, and also black pieces of chromate of iron. From this latter circumstance, Dr. Meade is induced to think, that all the noble or green serpentines are coloured by the green oxide of chrome.

1817, *May* 16.

An extract of a letter was read, from Mr. John Hanton of Lickbey in the Rosses, addressed to T. F. Berger, M.D. giving an account of the effects of the Storm of Dec. 4, 1811, in which the Saldanher was lost in Lough Swilly.

"I have made very particular enquiry relative to the kind of fish cast out by the storm of the 4th of last December on this coast, and the circumstances attendant thereon. On the shores of the isle Anasmor, lobsters, craw-fish, sea carp (called in Irish ballan) ling, heach, glamin, whiting, haddock, sprat, cod, and pollock, were cast on shore. On the shores of the main land, all the above kinds (except lobsters and craw-fish) with the addition of eels large and small, and a brown kind of fish about fourteen inches long, never before noticed here, with a large head and small body, supposed a mullet. The maws and gills of all were quite filled with sand, whence it would appear that from the furious agitation of the sea, the sand became so blended with it, that the fish were suffocated. No flat-fish were found dead; the greatest quantity of fish were found in shallow sandy bays: such effects have not occurred in the memory of the oldest man now living.

"We may judge of the uncommon depth to which the agitation of the sea reached during that storm, from the known depth at which the above sorts of fishes are generally caught; thus eels are fished in fifteen fathoms, and cod in from twenty to thirty fathoms; but it appears that at the approach of a storm, fishes of any kind go before it, passing into less deep water than they use to live in. It is admitted that the agitation of the sea in the most violent storms does not usually penetrate to more than seven feet deep."

1817, *Nov.* 21.

An extract of a letter from Robert Austin, Esq. M. G. S. of Bridgewater, was read; it was accompanied by a specimen of coralloidal arragonite.

"You are aware that the chief material of the Quantock Hills in this county is grauwacke, and that they are penetrated through a great part of their length by a vein of mountain limestone. In a quarry, situate six miles to the west-south-west of Bridgewater, near the village of Merridge, is a fissure in this limestone rock, which for a few years past has been famous for producing calcareous stalactites and stalagmites of considerable beauty, but not very essentially different from those produced in many limestone caverns of this and other countries; this fissure has lately been somewhat cleared and explored to a greater extent than before.

"I visited this place about three weeks since, and after working my way in the fissure of the limestone to the distance of about forty yards from the entrance, I found the passage there so contracted, I could not proceed further until it was enlarged, when it opened into a cavern in the grauwacke, of perhaps twenty yards in length, six to ten yards in breadth, and from three to six feet in height towards the middle: the roof, forming an irregular arch, running down to the floor on each side. About one-third of the surface of this roof I found studded and frosted over in patches with stalactites of coralloidal arragonite, the branches of which extended to a great length in all directions, in straight and variously curved lines. The cause of the difference observable between the common calcareous stalactites of the outer fissure and those of the inner cavern, which consist of coralloidal arragonite only, appears to me worthy of investigation.

"The fissures and cavern are kept in a constant state of humidity by water penetrating through the superincumbent ground, which is but a few yards in depth. The vapour arising from this in the cavern is considerable, and I am informed, often appears issuing from the mouth of the fissure in cold weather."

1818, *January* 2.

An extract of a letter from Capt. D. Carmichael, F. L. S. on the geological structure of part of the Cape of Good Hope, was read.

"The Table mountain and the Lion's head rest upon a base of granite; Green-point, Table valley, and the Devil's hill, on a base of schistus, of which the whole of the Lion's back is likewise composed. The granite extends up to the rocky crown of the Lion's head, an elevation of nearly 1500 feet; and the declivity of the mountain is strewed with enormous masses of it, rounded by successive exfoliations, and entirely detached from the soil. On the side of the Table mountain, the space on which the granite is visible is contracted to about 500 feet, and occupies the centre of the declivity.

At the spot called Sea Point, the waves have washed away all the loose earth, and left the rock exposed for a considerable extent. Here the granite and the schistus come in contact, and the manner in which their union has been accomplished it would be difficult to explain on any known theory of geology. In the space of 200 yards along the shore, the reef is a chaotic mixture of these two rocks, each predominating in the mass as you approach its respective side, where it is pure and unmixed. In some parts they form alternate layers of various diameter; in others, fragments of the schistus of all figures and sizes lie imbedded in the granite, which appears to have pervaded their minutest fissures. Between this mixed mass, however, and the pure schistus, there is interposed a rampart of granite, apparently different from the common sort, which, for about 200 yards is uncontaminated; but as it approaches the schistus, becomes mingled with it in the same manner as the granite. From this to Green Point, and extending through Bobben Island, a distance of about twelve miles, the schistus is pure, and stands in strata approaching within a few degrees of a vertical position, inclining in some parts to the eastward, in others to the opposite point.

Close to the path which leads from Cape town to the summit of the Table mountain, there runs a stream, which, at the point where the granite and the schistus meet, has carried off the superincumbent earth, and exposed the surface of the rock from ten to twenty yards in diameter, and about 200 yards in length, sinking at an angle of about thirty degrees. Along the whole of this space the schistus is intersected by veins of granite, varying from three feet in diameter to as many lines. These veins branch off in all directions, some straight, others twisted into the most fantastic convolutions. In the face of the rampart which borders the channel on each side, the veins are equally conspicuous. But here they, as well as the schistus, are in a state of disintegration, and crumble under the pressure of the layers.

In walking along the shore from Campo Bay to Sea Point, you meet with numerous veins of basalt in the granite, varying in diameter from an inch to ten feet, and branching in as many directions as those of the granite with schistus. Here also you will frequently meet with detached blocks of schistus imbedded in the granite.

The sandstone which forms the upper part of the Table mountain, Lion's head, and Devil's hill, lies in horizontal strata, intersected by vertical fissures. It is of a siliceous nature, and encloses rounded nodules of quartz."

1818, *June* 19.

A notice was read concerning volcanic chromate of iron. By Henry Warburton, Esq. M. G. S.

The author, on presenting to the Society a specimen from the extinct volcanoes of Hildesheim in the ci-devant department of the Kyll, consisting of granular peridot, coloured emerald-green by Chrome, and enveloping minute grains of chromate of iron, takes occasion to remark that the metal chrome has not hitherto been enumerated amongst the matters ejected by volcanoes. On the presumption of chrome being excluded from volcanic matters, M. Sementini, professor of chemistry at Rome, has founded an argument, by which he endeavours to prove that a red earth, which fell in Calabria* during a storm, is of meteoric origin. Having detected chrome in this earth, this metal, he argues, being an ingredient of meteoric but not of volcanic bodies, the earth is probably of meteoric nature. The specimen, however, from Hildesheim, destroys the grounds of this reasoning; and it is most probable that the earth from Calabria, since it contains crystals of pyroxene, is volcanic.

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* Journal de Physique. March 1818.

1818, *Dec.* 4.

A letter from Edward L. Irton, Esq. was read, containing some further information respecting one of the vitreous tubes found at Drigg in Cumberland, an account of which was inserted in the 2d volume.

"The remains of the third sand tube at Drigg have been discovered. Within the two first feet, we passed that bed of pebbles which (as has been formerly stated), diverted the direction of the tube. Following it downwards, within two feet more we came to a bed of smaller ones, closely bedded in wet sand; through this the electric matter had apparently penetrated with difficulty, but with great force, as it adhered with strong vitreous firmness to every little pebble of the size of a kidney-bean or less that stood in its way. Its course through this wet sand was extended to the depth of nearly eight feet, when the tube became so very contorted and twisted in its course by the different pebbles it met with, as to assume a very different appearance. It passed two pebbles without adhering to either, though it was much flattened and compressed in its formation; more so than what you observed in the specimens you procured when here. In one instance it had the usual tubular appearance, but at the distance of eight or nine inches was completely solid without any central perforation; though on continuing its course lower down it again assumed the rugged and tubular shape.

"I have one or two specimens of a very singular conformation, where the perfect tube of half an inch diameter, meeting with a bed of pebbles of the size of kidney-beans, has dispersed and spread its agglutinating power, so as to form a mass of two and a half-inches in diameter, and in which the vitreous matter visibly surrounds each particle. In the course, however, of two or three inches more, it again assumes, on the opposite side of the mass, its usual tubular shape, and continues till it again meets with other obstacles.

" In its course about three feet from the surface, it had made an attempt to pass between two large pebbles about three-quarters of an inch asunder, by which effort it was much flattened, and its diameter much reduced; each pebble was partially vitrified, but no adhesion had taken place.

" After that, for four or five inches, though going through soft sand, it became much contorted, as fig. 1. pl. 39. The lower the tube went, the more it seemed inclined to produce ramifications, some of such minute smallness, as not to be handled without breaking, but yet more perfect tubes than the large ones. One specimen I have is formed, as in fig. 2. pl. 39, from a ramification only: the diameter of this complete little tube is not more than one-eighth of an inch, and its length about two inches.

" In its descent downwards, and at the depth of about six feet, it branched off in various directions, as in fig. 3. pl. 39. We followed the branch with minute accuracy, and the base terminated on a granite pebble, though not adhering to it, with a small ramification extending only a few inches. The diameter of the base of the tube, when it struck the pebble, was about one-quarter of an inch."

Note by the Editor.

As the former notice respecting these tubes had not been accompanied by an engraving, the present opportunity has been embraced of giving figures of some of the specimens in the Museum of the Geological Society. Fig. 4. Plate 39 represents about one-half in length of the largest specimen drawn of the natural size. Fig. 5 is one that is forked; and fig. 6, 7, 8 & 9 exhibit sections of various tubes.

1819, *April* 2.

An account of the Limestone of Plymouth, by the Rev. Richard Hennah, Chaplain to the Garrison of Plymouth, was read.

The bed of limestone which occupies that part of the vicinity of Plymouth that lies toward the sea, between the æstuaries of the Plym and Tamar, rises to an elevation of about 100 feet above highwater mark, as appears from an accurate measurement of the Hoe, a hill sufficiently central to afford a fair criterion of the general height of the adjoining eminences. The limestone dips towards the south or south-west, and runs in a direction nearly east and west. Its breadth from north to south does not exceed the distance of from a half to a quarter of a mile. Its length from east to west extends to many miles.

Towards its western extremity in the Dock-yard, and at the Devil's Point, we perceive it sinking into the sea; it re-appears, though only for a little space, below Mount Edgecombe, and behind the passage-house at Cremhill ferry; after which I do not apprehend that it is any where visible towards the west, except in a few confined patches or rocks. From the Dock-yard, eastward, its course may be observed uninterruptedly as far as the Plym, and across that river into the parish of Plymstock, from whence it may be traced, appearing occasionally, to a considerable distance.

The limestone, wherever I have been able to observe its contact with the rock beneath it, rests upon clay-slate. The calcareous strata adjoining the north side of the road over Stonehouse-hill, immediately before arriving at the quarries and lime-kiln at Mill Bay, are interrupted in a remarkable manner by the clay-slate which is protruded upwards through the limestone.

The colour of the limestone is various, though the prevailing one is light-blue, or grey, changing at times to dark-blue or nearly black, these again being marbled with infinitely various tints of red and other colours. This variety of colours, and the high polish which the stone is capable of receiving from its hard and close-grained texture, render it an article of some importance as a marble for the manufactory of slabs and chimney-pieces. The foot pavements also in the three towns of Plymouth, Stonehouse, and Dock, and their environs, are almost all formed of blocks from the limestone quarries, and it is in these pavements, after a shower of rain, that the beauty of our marble may best be observed.

Until within a recent period, it was a question whether the limestone of Plymouth contained any animal remains: the account of my having discovered these bodies in our rocks has been inserted in the 4th volume of the Society's Transactions. The accuracy of my former statements, however, having been called in question, I can now affirm that the proofs of the presence of organic remains in our limestone, are abundant and indisputable; and so generally indeed do these remains pervade almost every part of our limestone, that I can only wonder that they have remained so long unnoticed. Visible traces of them meet us at every step, and there is hardly a hill or quarry where they do not obtrude themselves to the view of the curious. They consist of madrepores, tubipores, millepores, corals, entrochi, and various univalve and bivalve shells, among which are the anomia terebratula, and producta.

The madrepores are not confined to any particular stratum in our limestone, but are discoverable in almost every part of it, although they are variable in their quantity, being sometimes not very distinctly visible, and at other times occurring in extensive masses or layers. The other animal remains are not diffused so generally or so plentifully, each of the remaining genera appearing to occupy a separate stratum; so that, even with regard to shells, I have not found the univalves and bivalves mixed together, but severally occupying strata peculiar to themselves. Thus it will be seen, that in the Dock-yard, on the western side of Mount Wise, at Sandy Cove, and in Catdown, bivalves retaining much of their shelly character prevail; while on the south-western side of Stonehouse-hill, at the eastern end of Mount Wise, or the eastern Hoe under the citadel, and at the quarry on the eastern side of Catdown, the shells are univalves, whose substance partakes of the nature of the surrounding matter.

I now proceed to mention the particular spots where organic remains are to be found, beginning with the western extremity of the limestone, and advancing towards the eastern.

At the distance of about 150 yards to the east of the Devil's Point, on the south side, we find, *in situ*, a marble of a most striking appearance, composed of stellated madrepores, of an almost pure white colour, imbedded in a blood-red matrix. Stellated madrepores, and the vertebral columns of encrini, are to be met with in that hill in greater perfection than at any other place in this neighbourhood.

In the Dock-yard I have obtained entrochi, corallites, and bivalve shells, retaining much of their shelly character; there are also many imperfect fragments of other animal remains, of which I am not able to give the names.

On the western side of Mount Wise I have frequently met with bivalve shells, retaining also their shelly appearance, together with great quantities of madrepores, columns of the encrinus, and fragments of other animal bodies, and among these an orthoceratite.

Shells, which I believe are univalves, may be seen without difficulty in a part of the rock of Mount Wise that is uncovered, a little to the east of the battery, not far from the path-way that leads from the port-admiral's house to the navy stairs below. These shells are of a harder texture than the shells before noticed, and retain less of their natural appearance. The contents of this part of the hill resemble those of the south-western part of Stonehouse-hill, which we shall next describe.

Immediately on passing the last houses leading from Stonehouse to Plymouth, over the hill by the south side, I have found above and below the road, detached fragments, lying several feet under the present surface, differing but little from the solid rocks near them, containing, besides madrepores, many species of univalve shells so blended with the surrounding matter, as to form a solid mass, so that it has been with difficulty that I have obtained from these fragments any perfect specimens of shells. This stone is of a dark colour, and is capable of receiving a fine polish, by which its shells and madrepores are rendered beautifully distinct.

I have lately observed the presence of madrepores, entrochi, and shells, in the limestone raised from several pits opened on the north side of Stonehouse-hill for building the houses in Union-street, leading from Stonehouse to Plymouth. Madrepores and entrochi are contained in considerable quantity in masses of blue and grey limestone mixed with clay-slate, raised from a well at the back of the same houses.

At Mill Bay and Sandy Cove, which connect the west Hoe with Stonehouse-hill, the madrepores, tubipores, millepores, entrochi, corals, and bivalve shells are in great abundance, and are visible at almost every step: particularly where the limestone and clay-slate join, and are intimately blended or alternate with one another.

At Mill Bay, behind the coke-kiln, madrepores are abundant from the surface to the lowest part of the rock that can be seen.

Not far from Sandy Cove, upon the east Hoe, nearly under the citadel, I have obtained shells that are all univalves. In texture they are close-grained, hard, compact, and of the colour and substance of the surrounding matter, much resembling in their appearance those from Stonehouse-hill.

Immediately on crossing the water from the Victualling-office point, adjoining the citadel, to Tate's Hill and Queen Anne's Battery, an abundance of animal remains, although no shells, appear, particularly at the latter place. At Queen Anne's Battery, besides entrochi and many varieties of madrepores, I have observed what I conceive may be an alcyonium.

At a little distance from hence, in Deadman's Bay, near the quarry, madrepores, tubipores, and bivalve shells, with other organic remains are to be seen; and in a quarry on the opposite side of Catdown, across the road to the eastward, madrepores, tubipores, and univalve shells are found. Advancing still to the eastward as far as Prince rock and the Flying bridge, I there find entrochi, madrepores, and a fossil, of which I have collected fine specimens, and which I believe to be an orthoceratite.

Thus from the Tamar to the Plym, over a distance of nearly three miles, animal remains pervade the whole bed of the Plymouth limestone.

With regard to metallic veins, the limestone appears to be entirely free from them; for I have never heard that any symptoms of one were ever discovered in any of the quarries that have hitherto been opened. Indications of the presence of iron and manganese may occasionally be detected, serving as colouring matter, in particular spots; but these metals are always thinly spread, and are never found in any quantity. I have observed spots of pyrites in fragments of limestone taken out of a well behind the houses on the south side of Union street, Stonehouse; and among the fragments of rock raised from the solid ground in a new well on the north side of the same street, I have found specimens of limestone and slate containing animal remains and pyrites blended together.

Quartz occurs mixed with the limestone in some large fragments near the wall at the western end of Mount-wise, and also in some of the rocks forming the cliffs to the eastward of the Devil's point; but these instances are rare, and the quartz is small in quantity.

The caves which occur in the limestone of Plymouth afford stalactitical concretions in great variety of form, and in considerable abundance. Numerous forms of crystallized calcareous spar are also to be met with in our district, among which may be enumerated the primitive and inverse rhomboids, and an acute rhomboid, the hexagonal prism, and an acute dodecahedron in the greatest perfection. Some fragments of crystals, which I possess, are beautifully transparent, and of unusual size; but such specimens are not common, and are now difficult to be procured.

1821, *March* 2.

A letter from James Vine, Esq. Treas. G. S. was read, containing a notice on a method of hardening gypsum, lately discovered. It appears that if gypseous alabaster be heated considerably, and then immerged in water, it acquires a degree of hardness so great as to admit of a polish like marble, and may then be used for making slabs, and for other œconomical purposes.

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I. *Donations to the Library.*

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June 21.	Journal de Physique for February, 1817.	Robert Ferguson, Esq. Memb. G. Soc.
30.	Annals of Philosophy for July, 1817, by Dr. Thomson.	The Editor.
July 7.	Journal of Science and the Arts, No. 6, edited at the Royal Institution of Great Britain.	The Royal Institution of Great Britain.
	Transactions of the Asiatic Society, Vol. 12.	Asiatic Society.
9.	An account of some fossil remains of the Rhinoceros, found in a cavern in the limestone rock at Plymouth.	Sir Everard Home, Bart.
17.	Journal de Physique for March and April, 1817.	Robert Ferguson, Esq. Memb. G. Soc.
19.	Annales des Mines, Vol. 1st.	Conseil des Mines.
31.	Annals of Philosophy for August, 1817, by Dr. Thomson.	The Editor.
Aug. 30.	Annals of Philosophy for September, 1817, by Dr. Thomson.	The Editor.
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	Memoria sopra una nuova specie de Minerale scoperta in Liguria, dal Signor Professore Domenico Viviani.	
	Voyage dans les Apennins de la ci-devant Ligurie pour servir d' introduction a l'Histoire Naturelle du Pays, par Prof. Viviani.	The Author, by the hands of Professor Playfair.
31.	Annals of Philosophy for Nov. 1817, by Dr. Thomson.	The Editor.
Nov. 21.	Traité des caractères Physiques des Pierres Precieuses pour servir a leur determination lorsqu'elles ont ète taillées, par M. l'Abbe Haüy. For. M.G.S.	M. l'Abbe Haüy, For. Memb. G. Soc.
21.	Recherches tendantes a determiner l'importance relative des formes Cristallines et de la composition Chimique dans la determination des espèces Minerales, par F. S. Beudant, For. M.G.S.	The Author.
21.	Conchiologia Fossile Sub-appennina con osservazioni Geologiche sugli Appennini e sul Suolo adjacente, da G. Brocchi, For. Mem. G. S. Membro del R. Istituto Italiano, &c. 2 vols. 4t°	Charles Stokes, Esq. Sec. G. Soc.
Dec. 5.	Annals of Philosophy for December, 1817, by Dr. Thomson.	The Editor.
	Histoire Naturelle des Animaux sans vertèbres, par M. de Lamarck, vol. 4.	C. Stokes, Esq. Sec. G. Soc.
19.	Journal de Physique for July, August, September, and October.	Robert Ferguson, Esq. Memb. G. Soc.
	Coup d'Oeil Geognostique sur le nord de l'Europe en general, et particulierement de la Russie, par le Cit. G. de Razoumowsky, de l'Ac. Roy. des Sciences de Stockholm, &c.	Hon. W. T. H. Fox Strangways, Memb. G. Soc.
	Essai sur la Turquoise et sur la Calaite, par Gotthelf Fischer.	....
	Description of the Collection of Minerals belonging to the Œconomical Society at St. Petersburgh.	M. Charles Etter.
	Rules of the Imperial Public Library at St. Petersburgh.	....
1818.		
Jan. 2.	An account of the Skeleton of the Mammoth, by Rembrandt Peale.	H. Warburton, Esq. Vice-Pres. G. Soc.
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	Journal de Physique for November, 1817.	Robert Ferguson, Esq. Memb. G. Soc.
	The Emporium of Arts and Sciences, conducted by John Redman Coxe, M.D. Prof. of Chem. Univ. of Pennsylvania; vols. 1st and 2nd.	The Editor.

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	Annals of Philosophy for January 1818, by Dr. Thomson, Arthur Aikin, Esq. and Dr. Bostock.	The Editors.
	Ordnance Survey of Great Britain, part the 6th, containing nearly the whole of Surrey.	Colonel Mudge, Memb. G. Soc.
16.	Transactions of the Literary and Philosophical Society of New York, vol. 1st.	Philosophical Society of New York.
	Journal of Science and the Arts, edited at the Royal Institution of Great Britain, No. 8.	Royal Institution of Great Britain.
Feb. 20.	Voyage aux Regions Equinoxiales du Nouveau Continent, par Alex. de Humboldt, et A. Bonpland, redigé par A. de Humboldt. 4 vols. 8v°	M. le Baron Von Humbolt, For. Memb. G. Soc.
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	Syllabus of Lectures in Mineralogy, by Edward Daniel Clarke, LL.D.	The Author.
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	Memoires de la Societé d' Histoire Naturelle de Paris. 1 vol. 4t°, Paris.	....
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	Actes de la Societé d'Histoire Naturelle de Paris. 1 vol. fol. 1792.	....
	Catalogue of Shells, arranged according to the Linnean System, by W. Wood, F.R.S.	The Author.
Mar. 6.	Memoir of the Life of the late Rev. Wm. Gregor, by John Ayrton Paris, M.D.	The Author.
	Annals of Philosophy for March, 1818.	The Editors.
April 3.	Annals of Philosophy for April.	....
	Journal de Physique for January, 1818.	Robert Ferguson, Esq. Memb. G. Soc.
	Journal of Science and the Arts, edited at the Royal Institution of Great Britain. No. 9.	Royal Institution of Great Britain.
17.	Journal de Physique for February 1818.	Robert Ferguson, Esq. Memb. G. Soc.
May 1.	Lettera del Sig. Brocchi, Professore di Mineralogia nell' Universita di Roma, sopra alcuni ammassi colonari basaltini del territorio di Viterbo.	The Author.

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	Annals of Philosophy for May, 1818.	The Editors.
	Reise durch Skandinavien in den Jahren 1806 and 1807, von Joh. Fr. Ludw. Hausmann. 4 vols. 8v° Gottingen, 1811, 1812, 1814.	G. B. Greenough, Esq. Pres. G. Soc.
	Transactions of the Linnean Society; Vol. 12, Part 1st.	Linnean Society.
15.	A Selection of Facts, from the best authorities, arranged so as to form an Outline of the Geology of England and Wales, with a Map and Section of the Strata, by Wm. Phillips, M.G.S.	The Author.
	Journal de Physique for March, 1818.	Robert Ferguson, Esq. Memb. G. Soc.
June 5.	Annals of Philosophy, June, 1818.	The Editors.
	La Orictognosia, escrita en Aleman, por D. Juan Federico Guillermo Widenmann, y traducida, por Don Christiano Hengen, 2 tom.	
	Das Wissenswürdigste aus der Gebergskunde, zusammengetragen von Christoph. Friedrich Jasche, Gräflich-Stolberg Wernigerodischem, Berg-Commissarius, 1811.	Henry Heuland, Esq. For. Sec. G. Soc.
	Transactions of the Linnean Society, Vol. 12th, part 1st.	Linnean Society.
	Geognostische Umrisse Von Frankreich, Grossbrittanien, einem theile Teutschlands, und Italien, von Moritz von Engelhardt, und Karl von Raumer.	Henry Heuland, Esq. For. Sec. G. Soc.
	Bedeutung und Stand der Mineralogie, von Karl Cæsar von Leonard.	....
19.	On the Safety Lamp for Coal Mines, with some researches on Flame, by Sir Humphry Davy, Bart. Mem. G. Soc.	The Author.
	Transactions of the American Philosophical Society, held at Philadelphia; vol.1st, new series.	Philosophical Society at Philadelphia.
	Denkschriften der Königlichen Akademie der Wissenchaften zu München fur die jahre 1814 and 1815. Band 5.	Royal Academy of Science at Munich.
	Mineralogisch-chemische Untersuchungen des Triphans und Tantalits von Leonhard und Vogel.	The Authors.

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June 19.	Zu Werners Andenken, gesprochen in der Versammlung der Königlichen Akademie der Wissenshaften zu München, am 25 October, 1817, Von Karl Cæsar Ritter von Leonhard.	The Author.
	Explication de Playfair sur la Theorie de la terre par Hutton, et examen comparatif des Systèmes Geologiques, fondés sur le feu et sur l'eau par M. Murray, en reponse à l'explication de Playfair, traduits de l'Anglais, par C. A. Basset.	Charles Stokes, Esq. Memb. G. Soc.
	Memoire sur des Bois de Cerfs Fossiles trouves en creusant un puits, dans les environs de Montelimar en Dauphiné, 1775.	....
	De la Mineralogie, par J. A. H. Lucas, For. Mem. G. S.; article extrait du 21er vol. du Nouveau Dictionnaire d'Histoire Naturelle, 2d. edition.	The Author.
Nov. 6.	On the Mechanism of the Universe, by Sir Richard Phillips.	The Author.
	The scientific Tourist through England, Wales, and Scotland, by Thomas Walford, Esq. M.G.S. 2 vols. 8vº.	The Author.
	Annals of Philosophy for July, August, September, and October, 1818.	The Editors.
	Catalogo Ragionato di una Raccolta di Rocce disposto con ordine Geographico, per servire alla Geognosia dell' Italia de G. Brocchi, Mem. Dell. Istituto. For. M.G.S.	The Author.
	Journal of Science and the Arts, edited at the Royal Institution of Great Britain. Nos. 10 and 11.	Royal Institution of Great Britain.
	Journal de Physique for April, May, June, July, and August, 1818.	Robert Ferguson, Esq. Memb. G. Soc.
	Transactions of the Royal Irish Academy, vol. 13th, part 1st.	Royal Irish Academy.
	An Introductory Lecture, delivered in 1816 at the Royal Dispensary for Diseases of the Ear, by J. H. Curtis, Esq.	The Author.
26.	Annales des Mines, Vol. 2, 1817, and No. 1 of Vol. 3.	Conseil des Mines.
	Annals of Philosophy for November 1818.	The Editors.
	Observations on a Tour through the Western Counties, by W. G. Maton, M.D.	The Author.
	Memoires Geologiques sur les terrains formés sous l'eau douce par les mollusques vivans sur la terre ou dans l'eau non salée, par J. Daudébart de Ferrussac.	The Author.
Dec. 4.	Lobrede auf Karsten, gelesen in der offentlichen Versammlung der academie der Wissenchaften, am 3 July, 1814, von Leopold v. Buch.	Henry Heuland, Esq. For. Sec. G. Soc.
	Von den Geognostichen Verhältnissen des Trapp-Porphyrs, von Leopold von Buch.	....

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	Journal de Physique for September, 1818:	Robert Ferguson, Esq. Memb. G. Soc.
	An account of the History and present State of Galvanism, by John Bostock, M.D. M.G.S.	The Author.
	Annals of Philosophy for December, 1818, by Dr. Thomson.	The Editor.
18.	Journal de Physique for October, 1818.	Robert Ferguson, Esq. Memb. G. Soc.
22.	Tableau Physique et Topographique de la Tauride tiré du Journal d'un Voyage fait en 1794, par P. S. Pallas. 4t°, St. Petersburgh, 1795.	Hon. W. T. H. Fox Strangways, Memb. G. Soc.
	Tableau des Provinces situées sur la côte occidentale de la mer Caspienne entre les fleuves Terek and Kour.	....
1819.		
Jan. 1.	An Index to the Geology of the Northern States of America, with a transverse Section from Catsgill mountain to the Atlantic, by Amos Eaton, A.M. Lecturer on Natural History and Chemistry, New York.	Right Hon. Earl of Selkirk, Memb. G. Soc.
4.	Journal of Science and the Arts, edited at the Royal Institution of Great Britain. No. 12.	Royal Institution of Great Britain.
9.	Essai sur la Turquoise et sur la Calaite, par Gothelf Fischer, Vice-Pres. de l'Academ. Imp. Med. Chir. Moscow, 1818.	The Author.
	Journal de Physique for November, 1818.	Robert Ferguson, Esq. Memb. G. Soc.
20.	Observations on the Structure and mode of Growth of the Grinding Teeth of the Wild Boar, and Animal Incognitum, by Everard Home, Esq. F.R.S.	William Clift, Esq. Memb. G. Soc.
	Account of some remarkable Caves in the Principality of Bayreuth, and of the Fossil Bones found therein, extracted from a Paper sent with specimens of the Bones, as a present to the Royal Society, by his Most Serene Highness the Margrave of Anspach, &c.; likewise Observations on the Fossil Bones, by the late John Hunter, F.R.S. communicated by Mr. Home.	....
	The Transactions of the Royal Irish Academy, Vol. 1 to 12, and Vol. 13, part 1.	Royal Irish Academy.
	Annals of Philosophy for February, by Dr. Thomson.	The Editor.
	Histoire Naturelle des Animaux sans vertèbres, par M. le Chevalier de Lamarck, vol 5.	C. Stokes, Esq. Memb. G. Soc.
Feb. 1.	Memoirs of the American Academy, vol. 4, part 1.	American Academy.
5.	Journal de Physique for December, 1818.	Robert Ferguson, Esq. Memb. G. Soc.

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Feb. 26.	Annals of Philosophy for March, 1819, by Dr. Thomson.	The Editor.
	Ordnance Survey of Great Britain, part 7th, containing the central part of Wiltshire, a portion of Somersetshire, and the remaining part of Hampshire.	Colonel Mudge, Memb. G. Soc.
Mar. 1.	Transactions of the Royal Geological Society of Cornwall, vol 1st.	Captain Colby, Memb. G. Soc.
28.	Annals of Philosophy for April, 1819, by Dr. Thomson.	The Editor.
April 1.	Journal of Science and the Arts, edited at the Royal Institution of Great Britain.	Royal Institution of Great Britain.
	Journal de Physique for January, 1819.	Robert Ferguson, Esq. Memb. G. Soc.
2.	Considerations sur les Pierres, les masses de fer, et les poussières dites meteoriques, par S. Leman.	The Author.
	De la Cristallisation considerée Geometriquement et Physiquement, ou traité abregé de Crystallographie suivi d'un precis de nos connoissances actuelles sur les phenomènes physiques de la cristallisation, par A. J. M. Brochant de Villiers.	The Author.
20.	Mineralogisch-chemische Untersuchungen des Triphans und Tantalits von Leonhard und Vogel. 4t°. Munich, 1818.	
	Statuts de la Societé Helvetique des Sciences Naturelles. 4t°. Lausanne, 1818.	
	Discours prononcé à Lausanne Juillet 27th, 1818, en ouvrant la première Seance de la reunion periodique de la societé Helvetique des Sciences Naturelles, par D. A. Chavannes, Le President de cette année. 8v°, Lausanne, 1818.	Jos. Marryatt, jun. Esq. Memb. G. Soc.
22.	Essai sur la Turquoise et sur la Calaite, par Gotthelf Fischer. 8v°, Moscow, 1818.	The Author.
	Essai sur la Pellegrina, ou la Perle incomparable des freres Zozima, par G. Fischer. 8v°, Moscow, 1818.	The Author.
	Memoires de la Societe Imperiale des Naturalistes de Moscow, tom 5. 4t°. Moscow, 1817.	M. Gotthelf Fischer.
23.	Journal de Physique for February, 1819.	Robert Ferguson, Esq. Memb. G. Soc.
24.	Remarks on the Account of the late Voyage of Discovery to Baffins Bay, published by Captain J. Ross R. N., by Captain Edward Sabine, R. Ar.	The Author.
May 3.	Annals of Philosophy for May, 1819, by Dr. Thomson.	The Editor.
12.	Leçons d'Anatomie Comparée, de G. Cuvier, Membre de l'Institut. National, &c. receuillies et publiées sous ses yeux, par C. Dumeril, Chef des travaux Anatomiques de l'Ecole de Medicine de Paris, 5 tom. 8v° Paris, 1805.	C. Stokes, Esq. Memb. G. Soc.

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	On the Mammoth, or Fossil Elephant, found in the ice at the mouth of the River Lena, in Siberia, with a Lithographic plate of the Skeleton, from vol. 5 of the Memoirs of the Imperial Academy of Sciences at St. Petersburg. 4t°. London, 1819.	....
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	An Elementary Introduction to the knowledge of Mineralogy, by W. Phillips, M.G.S. 8v°. London, 1819.	The Author.
	Institutions Geologiques par Scipion Breislak, Membre de l'Institut. Imperial et Royal de Lombardie, &c. 3 vols. 8v°. Milan, 1818, and a volume of Plates.	The Author.
	King Coal's Levee, or Geological Etiquette, with explanatory notes; to which is added, the Council of the Metals, by John Scafe, Esq. 2nd. edit. Alnwick, 1819.	The Author.
21.	A Critical Examination of the first Principles of Geology, in a series of Essays, by G. B. Greenough, Esq. Pres. G. S. 8v°. London, 1819.	The Author.
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	Annals of Philosophy for June, 1819, by Dr. Thomson.	The Editor.
July 25.	Annals of Philosophy for July, 1819, by Dr. Thomson.	....
Aug. 7.	Journal de Physique for April, 1819.	Robert Ferguson, Esq. Memb. G. Soc.
8.	Supplement to vol. 13, Annals of Philosophy, Dr. Thomson.	The Editor.
	Journal de Physique for May, 1819.	Robert Ferguson, Esq. Memb. G. Soc.
	Annals of Philosophy for August, 1819, by Dr. Thomson.	The Editor.
	Essay on Chemical Analysis, by J. G. Children, Esq. Mem. G. Soc.	The Author.
	Saggi Geologici degli state di Parma e Piacenza, dal Guidice Guiseppe Cortosi, Professore Onorario di Geologia. 4t°. Piacenza, 1819.	The Author.
	The Quarterly Journal, No. 14, edited at the Royal Institution of Great Britain.	Royal Institution of Great Britain.
Sept. 10.	Essai sur la Turquoise et sur la Calaite, par Gotthelf Fischer. 2d edit. Moscow, 1818, 8v°.	Hon. W. H. T. Fox Strangways, Memb. G. Soc.
	Memoires de la Societé Imperiale des Naturalistes de Moscow, tom 5. Moscow, 1817.	....

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Oct. 29.	Annals of Philosophy for September, October, and November, 1819, by Dr. Thomson.	The Editor.
	Journal de Physique for June, July, and August, 1819.	Robert Ferguson, Esq. Memb. G. Soc.
	Transactions of the Linnean Society, vol. 12, part 2d.	Linnean Society.
	Histoire Naturelle des Animaux sans Vertèbres, par M. le Chevalier de Lamarck, vol. 6, part 1.	C. Stokes, Esq. Memb. G. Soc.
Nov. 8.	Journal de Physique for September, 1819.	Robert Ferguson, Esq. Memb. G. Soc.
16.	Note sur une couche de Lignite, trouvée récemment à Auteuil par M. Becqueril.	The Author.
17.	Geological and Mining Survey of the Connaught Coal District in Ireland, by Richard Griffith, jun. Esq. Hon. M.G.S. 8v°. Dublin, 1818.	The Author.
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7.	Account of a Voyage of Discovery to the West Coast of Corea and the Great Loo-choo Island, by Capt. Basil Hall, R.N. M.G.S.	The Author.
17.	Traité de Geognosie par J. B. d'Aubuisson de Voisins. 2 vols. 8v°. Strasbourg, 1819.	The Author.
30.	Annals of Philosophy for January, 1820, by Dr. Thomson.	The Editor.
	Journal de Physique for October, 1819.	Robert Ferguson, Esq. Memb. G. Soc.
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	Annals of Philosophy for March, 1820, by Dr. Thomson.	The Editor.
4.	Annales des Mines, vol. 3, and Livr. 1, 2, & 3, of vol. 4.	Conseil des Mines.
April 5.	Journal of Science and the Arts, No. 17, edited at the Royal Institution of Great Britain.	Royal Institution of Great Britain.
	Annals of Philosophy for April, 1820, by Dr. Thomson.	The Editor.
6.	Tentamen Chemico-mineralogicum de Grenatis, Mag. Johanne Gadolin, Chim. Prof.	The Author.
	Sopra Alcuni Miglioramenti all' amalgamazione delle materie Aurifere et Argentifere, memoria del. P. D. Ermenegildo Pini.	Aug. Boz. Granville, M.D. Memb. G. Soc.
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	Saggio di una Nuova Teoria della Terra, by the same.	....
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	Annals of Philosophy for May, 1820, by Dr. Thomson.	The Editor.
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	Projection of the Globe on the Cylinder of a Meridian, with an accompanying Memoir; by Jas. Vetch, Capt. R. E.	The Author.
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28.	Sur les Ichthyolites ou les poissons Fossiles, par M. H. de Blainville.	The Author.
	Annals of Philosophy for June, 1820, by Dr. Thomson.	The Editor.
June 16.	Ordnance Survey of Great Britain, part 8th, containing the greater part of Kent, and portions of Surrey and Sussex.	Captain Colby, Memb. G. Soc.
	Journal de Physique for March, 1820.	Robert Ferguson, Esq. Memb. G. Soc.
	Annals of Philosophy for July, 1820, by Dr. Thomson.	The Editor.
	Journal of Science and the Arts, No. 18, edited at the Royal Institution of Great Britain.	Royal Institution of Great Britain.
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	Journal de Physique for April, 1820.	R. Ferguson, Esq. Memb. G. Soc.
	Journal de Physique for May, 1820.	....
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	Annals of Philosophy for August, September, October, and November, 1820, by Dr. Thomson.	The Editor.
	Journal of Science and Arts, No. 19, edited at the Royal Institution of Great Britain.	Royal Institution of Great Britain.
Nov. 4.	Esame Analitico dell' opera intitolata Institutions Geologiques, par Scipion Breislak. 8v°. Milano, 2 copies.	The Author.
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	Journal de Physique for June and July, 1820.	R. Ferguson, Esq. Memb. G. Soc.
	Annals of Philosophy for December, 1820, by Dr. Thomson.	The Editor.
19.	American Journal of Science, conducted by Benj. Silliman, M.D. Prof. Chem. vol. 1, and No. 2 of vol. 2. New York.	The Editor.
	Journal de Physique for August, 1820.	R. Ferguson, Esq. Memb. G. Soc.
	Annals of Philosophy for January, 1821, by Dr. Thomson.	The Editor.
	Journal of Science and Arts, No. 20, edited at the Royal Institution of Great Britain.	Royal Institution of Great Britain.

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	Transactions of the Royal Irish Academy, Vol. 13, part 2.	The Royal Irish Academy.
	Journal de Physique for Sepr. and October 1820.	Robt. Ferguson, Esq. Mem. G. Soc.
1821.		
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	Tables des memoires et Notices contenus dans les vingt volumes des annales du museum d'Histoire Naturelle.	Chas. Stokes, Esq. Mem. G. Soc.
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	Annals of Philosophy, for Feb. & March 1821, by Dr. Thomson.	The Editor.
	Elements of Mineralogy, by Richard Kirwan, Esq. F.R.S.	Right Hon. Earl Compton, Pres. G. Soc.
	Journal de Physique for Nov. 1820.	Rob. Ferguson, Esq. Mem. G. Soc.
	Remarks on a communication published in the 20th No. of the Journal of Literature, Science and the arts; by Sam. Parkes, Rd. Phillips, Phillip Taylor, J. G. Children, John Martineau, jun. John Bostock, M.D. and John Taylor.	The Authors.
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22.	Transactions of the Cambridge Philosophical Society. Vol. 1, part 1.	Cambridge Philosophical Society.
30.	Journal of Science, Literature, and the Arts, No. 21; edited at the Royal Institution of Great Britain.	Royal Institution of Great Britain.
April 2.	Voyages dans les deux Siciles, et dans quelques parties des Appenins par Spallanzani, Prof. de Hist. Nat. dans l'univ. de Pavie; traduit de l'Italien, 6 vol. 8v° Paris, an. 8.	C. Daubeny, M. D. Mem. G. Soc.
	Notice sur l'ancien royaume des Auvergnats et sur la ville de Clermont par Ant. Delarbre.	....
	A reply to an article contained in the 20th No. of the Journal of Science, by A. B. Granville, M.D.	The Author.
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	Memoire sur les substances minerales dites en masse qui entrent dans la composition des roches volcaniques; par P. Louis Cordier.	The Author.
	Memoire sur la montagne de sel gemme de Cardonne en Espagne: par P. Louis Cordier.	....

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April 2.	Transactions of the Royal Society of Edinburgh, Vol. 9, part 1.	Royal Society of Edinburgh.
	Journal de Physique, for Dec. 1820.	Rob. Ferguson, Esq. Mem. G. Soc.
	American Journal of Science and Arts, by Benj. Silliman, M.D. No. 2, of Vol. II, & No. 1, Vol. III.	The Editor.
	Notice Historique sur la vie et les ouvrages de Dolomieu par le Cn. Lacépéde. Paris 1820.	M. le Marquis de Drée. For. Mem. G. Soc.
May 2.	Annals of Philosophy, for May, 1820, by Rd. Phillips.	The Editor.
	Annales des Mines, 3d & 4th Livr. 1820.	Conseil des Mines.
	Mineral Conchology, No. 48, and 7 Prints of Fossil Shells, by Jas. Sowerby, Mem. G. Soc.	The Editor.
20.	Mineral Conchology Nos. 26 to 47, by Jas. Sowerby, Mem. G. Soc.	....
24.	Journal de Physique for Jan. 1821.	Rob. Ferguson, Esq. Mem. G. Soc.
30.	Annals of Philosophy for June, by Rich. Phillips.	The Editor.
	Mineral Conchology, No. 49, by Jas. Sowerby, Mem. G. Soc.	The Editor.
June 5.	Essai d'un exposé geognostico-botanique de la Flore du Monde primitif par Gaspard Comte de Sternberg, 1 cahier, Leipsic, 1820.	The Author.
	Description of two new species of Exocetus, by C. A. Le Sueur.	The Author.
	Neues systematisches conchylien-cabinet geordnet und beschrieben von Friedrich Heinrich Wilhelm Martini. 12 vols. 4t°. Nuremberg 1769.	Purchased out of the Fund for procuring cabinets, books, and maps.
	Annales du Museum d'histoire naturelle par les professeurs de cet etablissement; 20 vols. Paris.	....
	A descriptive catalogue of recent shells arranged according to the Linnean method, by Lewis Weston Dilwyn, F.R.S. 2 vol. 8v°. London 1817.	....
	A description of the Western islands of Scotland, including the Isle of Man, comprising an account of their geological structure, with remarks on their agriculture, scenery and antiquities, by John Mac Culloch, M.D., Vice-Pres. G. Soc.; 2 vol. 8v°. and a vol. of plates in 4t°. London, 1819.	....
	Edinburgh Philosophical Journal, vol. 1, 2, 3, 4, 8v°.	....
	Receuil des petrifactions, dessignées et gravées par G. H. Knorr, continué par J. E. Walch, 4 vols. folio. Nuremberg 1777.	....
	The natural history of Zoophytes, collected by John Ellis, and arranged and described by D. Solander, M. D. 4t°. London, 1786.	....
	The history and antiquities of Harwich and Dovercourt, by Sam. Dale. 4t°. London, 1730.	....
	Memoir du Museum d'histoire naturelle par les professeurs de cet establissement; Vol. 1, 2, and 3. 4to. Paris.	....

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	Essai sur l'histoire naturelle des corrallines, &c. par Jean Ellis; traduit de l'Anglois. 4t°. A la Haye, 1756.	....
	Histoire naturelle de la Montagne de St. Pierre de Maestricht, par B. Faujas Saint Fond, fol. Paris. An. 7 de la Rep. Fran.	....
	A Classification of Rocks, with descriptive synopses of the species and varieties; composing the Elements of Practical Geology; by John Mac Culloch M.D. M.G.S. 8v° London,1821.	....
	A Catalogue of English Fossils, by J. Woodward, M.D. 2 vol. 8v°. London. 1729.	....
	Martini Lister Historiæ Animalium Angliæ tres tractatus. 4to. Londini. 1678.	....
	The Natural History of Oxfordshire, by Robert Plott, LL.D. fol. Oxford. 1705.	....
	Jani Planci Ariminensis de conchis minus notis liber. 4t°. Romæ. 1760.	....
	Stratigraphical System of Organized Fossils; with references to the specimens of the original geological collection in the British Museum, explaining their state of preservation and their use in identifying the British Strata, by William Smith, 4t°. London. 1817.	....
	Jacobi Theodori Klein Naturalis dispositio echinodermatum, &c. edita et descriptionibus novisque inventis et synonimis auctorum aucta, a Nathanaele Godofredo Leske. fol. Lipsia. 1778.	....
	Strata identified by Organized Fossils, by William Smith. No. 1, 2, 3, 4. 4t°. London. 1819.	....
	Testacea Musei Cæsarei Vindobonensis quæ jussu Mariæ Theresiæ Augustæ disposuit et descripsit Ignatius Born. fol. Vindobonæ. 1780.	....
	The Natural History of Northamptonshire, by John Morton. fol. London. 1712.	....
	Index Testarum conchyliorum quœ adservantur in museo Nicholai Gualteri. fol. Florentiæ. 1742.	....
	Betrachtung der versteinerten Seesterne und ihrer Theile; von Christian Friedrich Schulzen. 4t°. Dresden. 1760.	... .

1821.	BOOKS.	DONORS.
June 5.	Ueber den innern Bau der See-und einiger ausländischen Erd-und Fluss-schnecken ein Bersuch von Johann Samuel Schröter. 4to. Franckfurt. 1783.	Purchased out of the Fund for procuring Cabinets, Books, and Maps.
	Die Geschichte der Flussconchylien mit vorzüglicher Rücskicht auf diejenigen welche in den Thüringischen Wassern leben, von Johann Samuel Schröter. 4to. Halle. 1779.	....
	Essai d'un exposé geognostico-botanique de la Flore du monde primitif par Gaspard Comte de Sternberg, 1st Cahier. fol. Leipsic.	The Author.
	Description of two new species of Exocetus by C. A. Le Sueur. 8vo.	The Author.
	Sur le gisement, ou position relative des Ophiolites, Euphotides, Jaspes, &c. dans quelques parties des Appenins par Alex. Brongniart, For. Mem. G. Soc. 8vo. Paris 1821.	The Author.

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Nov. 5.	Three drawings of a fossil from Charmouth.	H. T. De la Beche, Esq. Mem. G. Soc.
21.	Basaltic mountains; a series of engavings. 1 vol. folio.	Robert Hutton, Esq. Mem. G. Soc.
Dec. 19.	Section of the Chalk cliffs at Dover.	Wm. Phillips, Esq. Mem. G. Soc.
1818.		
Jan. 2.	Portrait of the late Prof. Werner, modelled in wax.	H. Heuland, Esq. For. Sec. G. Soc.
Feb. 20.	Map of part of North America with the strata in the United states, coloured.	Mr. Wm. Maclure.
	Meteorological table, extracted from the register kept at Kinfauns Castle. 1817.	J. Macculloch, M.D. Mem. G. Soc.
June 5.	Two Engavings exhibiting a comparison between the Sternum of the Ornithorhynchus Paradoxus and that of the fossil animal found at Lyme in Dorsetshire.	Sir E. Home, Memb. G. Soc.
	Plan of the works of the Harbour of Dunmore.	Alexr. Nimmo, Esq. Mem. G. Soc.
	Engraving of a Pearl.	—— Cole, Esq.
Nov. 6.	Section of the coast of England, from Burton to Beer-head.	H. T. De la Beche, Esq. Mem. G. Soc.
	Section of one of the Measures of Ironstone at Morley park Colliery near Belper, Derbyshire.	Tho. Robinson, Esq.
	Vue de Mont Beschtau du coté de l'Orient près de la rivière Essentouk.	Baron Vietinghoff, Petersburgh.

1819.	BOOKS.	DONORS.
Feb. 18.	A Map of England and Wales by A. Arrowsmith. 1818.	Dr. Wollaston, Mem. G. Soc.
26.	Sketch of the skeleton of an Ichthyosaurus found at Watchet. 1818.	G. Cumberland, Esq. Hon. Mem. G. Soc.
May 4.	Two sketches of parts of the fossil skeleton of an Ichthyosaurus in the possession of Mr. Morgan of Bristol.	....
7.	Table of the Strata in the environs of Petersburg, according to their order of Geological position.	Hon. W. T. H. Fox Strangways, Mem. G. Soc.
22.	Lithographic print of a head of one of the species of the animal from the Blue Lias, Lyme Regis, Dorsetshire, in the possession of H. T. De la Beche, Esq.	H. T. De la Beche, Esq. Mem. G. Soc.
June 6.	Sketch of the skeleton of an Ichthyosaurus found at Minehead.	Chas. Stokes, Esq. Mem. G. Soc.
Sep. 15.	Engraving of a Proteo-Saurus found in Lias at Lyme Regis in Dorsetshire.	Sir E. Home, Bart. Mem. G. Soc.
1820.		
Feb. 14.	A skeleton Map of Europe.	G. B. Greenough, Esq. Mem. G. Soc.
	Map of Saxon Switzerland.	....
	Map of the environs of Dresden.	....
Mar. 24.	Drawing copied from a print of the fossil Elephant found in Siberia.	C. Stokes, Esq. Mem. G. Soc.
June 16.	Print of the upper jaw of a fossil Crocodile from Havre in the museum of the Academy of Geneva.	H. T. De la Beche, Esq. Mem. G. Soc.
Aug. 3.	Drawing of a fossil leaf in iron stone from the neighbourhood of Whitby.	N. Winch, Esq.
Nov. 9.	Drawing of a fossil vegetable from the sandstone, Sussex.	Gid. Mantell, Esq. Mem. G. Soc.
4.	Drawing of a Fossil leaf from the white lias and another from the blue lias of Axminster, Devon.	H. T. De la Beche, Esq. Mem. G. Soc.
14.	Geological Map of the S. E. part of Sussex, by Gideon Mantell, Esq. M.G.S.	The Author.
1821.		
Mar. 30.	Print of a Trilobite, from Built in Brecknockshire.	H. T. De la Beche, Esq. Mem. G. Soc.
May 2.	Engraved portrait of Dolomieu.	M. le Marquis de Drée, For. Mem. G. Soc.

III. *Donations to the Cabinet of Minerals.*

1817.		DONORS.
June 21.	Fossil Vetebra and Rib from the Stonesfield slate.	Henry Warburton, Esq. Memb. G. Soc.
July 9.	Recent Shells.	Col. Stewart, Memb. G. Soc.
15.	Specimens of Simple Minerals.	G. B. Greenough, Esq. Memb. G. Soc.
17.	Specimens and Fossils from the Chalk.	G. Mantell, Esq.
19.	Specimens from Switzerland.	F. Berger, M.D. Memb. G. Soc.

1817.	SPECIMENS.	DONORS.
June 19.	Specimens of Molybdena and Manganese.	Rev. Mr. Mandell.
30.	Specimens from Greenland.	Sir Charles Giesecke, Memb. G. Soc.
Aug. 1.	Fossil Shells found with the bones of the Elephant near Walton.	Henry Warburton, Esq. V. P. G. Soc.
Sept. 13.	Specimen of Arragonite from a Cavern in the Quantock Hills	Robert Anstice, Esq. Memb. G. Soc.
30.	Fossils from the Grey Chalk marl near West Malling, Sussex.	Mr. Tucker, Corp. Ch. Col. Oxford.
	Specimens of Simple Minerals.	Arthur Aikin, Esq. Memb. G. Soc.
Oct. 6.	Specimens of Simple Minerals.	Joseph Marryat, Jun. Esq. Memb. G. Soc.
	Fossils from the Stonesfield Slate.	Henry Warburton, Esq. V. P. G. Soc.
	Various Specimens & Fossils, English & Foreign.	....
9.	Specimens of Carbonate and Silicate of Zinc.	....
13.	Specimens of Simple Minerals.	Charles Stokes, Esq. Memb. G. Soc.
31.	Fossils from the Breadon hills.	Edw. Berens Blackburn, Esq. Memb. G. Soc.
	Part of a Deer's horn found in gravel.	Rev. W. Buckland, Memb. G. Soc.
Nov. 4.	Specimens from Scotland	Capt. Vetch, Royal Eng. Memb. G. Soc.
	Specimens of Chalk fused by heat, and of Tufa from a boiler.	....
	Specimens of Simple Minerals.	Johann Rohatch, M.D.
	Specimens of Uranite from Cornwall, and crystallized Phosphate of Iron from ditto.	J. T. Cooper, Esq.
5.	Fossil tooth of a Fish from the Chalk.	C. Stokes, Esq. Memb. G. Soc.
	Specimens of Simple Minerals from North America	William Phillips, Esq. Memb. G. Soc.
	Specimens of English Strata.	N. Winch, Esq. Hon. Memb. G. Soc.
	Specimens from the Green Sand.	Wm. Phillips, Esq. Memb. G. Soc.
	Specimens from Haldon hill.	H. J. Brooke, Esq. Memb. G. Soc.
21.	Specimens from the neighbourhood of Babbacombe.	G. B. Greenough, Esq. Memb. G. Soc.
Dec. 5.	Specimens from the mines of Winslow, Cheshire.	Henry Warburton, Esq. Memb. G. Soc.
	Specimens of Primary Limestone from Perthshire.	J. Macculloch, M.D. Memb. G. Soc.
19.	Specimens of Simple Minerals, and of Rocks, from Italy.	Joseph Marryat, jun. Esq. Memb. G. Soc.
	Specimens of Magnesian Limestone.	William Danby, Esq.
	Calcareous Spar and Sulphate of Strontian.	G. Cumberland, Esq. Hon. Memb. G. Soc.
	Nodules of Clay Iron Stone, found at the bottom of the London Clay.	Capt. Colby, Memb. G. Soc.

1817.	SPECIMENS.	DONORS.
Dec. 19.	Specimens from the Cape of Good Hope.	Dr. Adam, Calcutta.
	Fossil Pentacrinus from the lias of Frethern Cliff on the Severn.	Rev. Robert Halifax, Memb. G. Soc.
	Fossil Chain Coral from Ledbury.	....
	Specimens from Devonshire and Cornwall.	G. B. Greenough, Esq. Memb. G. Soc.
1818.		
Jan. 2.	Specimen from the Great St. Bernard.	Ashhurst Majendie, Esq.
16.	Specimens of Rocks from Cornwall and the Continent.	G. B. Greenough, Esq. Memb. G. Soc.
	Specimen of siliceous casts of Perforations in a Belemnite.	T. Allen, Esq.
	Specimen of the Sand from the shore of Lago di Bolsenna.	Peter Ducane, Esq. Memb. G. Soc.
	Fossils from the Gault at Cambridge.	Henry Warburton, Esq. V. P. G. Soc.
	Magnetic Iron Sand from Hunstanton, and Antimonial Galena.	....
	Fossils of the Chalk.	Wm. Phillips, Esq. Memb. G. Soc.
Feb. 20.	Specimen of Bitumen from the Pitch Lake at Cuba.	Joseph Marryat, Junr. Esq. Memb. G. Soc.
	Amethystine Quartz, Cornwall.	H. J. Brooke, Esq. Memb. G. Soc.
	Specimens of crystallized Sulphur, and depositions from the hot springs in St. Michael's, one of the Azores.	....
	Specimens from Java.	Joseph Marryat, Junr. Esq. Memb. G. Soc.
	Specimens of Simple Minerals.	H. J. Brooke, Esq. Memb. G. Soc.
	Specimens from North America.	Mr. William Maclure.
	Specimens of the scales of Fish in Chalk, and a polished slab of Petworth Marble.	Gideon Mantell, Esq. Memb. G. Soc.
	Portions of two Fossil Jaws of the Elephant, with the Teeth, and a specimen of the Hertfordshire Pudding Stone.	Chas. Stokes, Esq. Memb. G. Soc.
	A Geological collection of Rocks from Freyberg.	Henry Heuland, Esq. For. Sec. G. Soc.
	Specimens of Manganese in Chalk.	Rev. J. Holme, Memb. G. Soc.
	Specimen from Cove, near Blackwater, Hants.	John Norris, Esq. Memb. G. Soc.
April 3.	Fossils from the Gibraltar Quarries, Woodstock.	Rev. W. Buckland, V. P. G. Soc.
17.	Specimen of the Grauwacke Rock in which the cavern in the Quantock hills, containing the arragonite, is found.	Robert Anstice, Esq. Memb. G. Soc.
	Specimens of Foreign Rocks.	Mon. C. A. Zipser of Neusohl in Hungary.
	Specimens of Simple Minerals.	H. J. Brooke, Esq. Memb. G. Soc.
	Chromate of Iron crystallized and compact, from Baltimore in North America.	R. Gilmor, Junr. Esq. of Baltimore.

1818.	SPECIMENS.	DONORS.
April 17.	Wood Coal from the Cape of Good Hope.	Rev. W. Buckland, V. P. G. Soc.
May 1.	Specimens from the vicinity of Bristol.	Geo. Cumberland, Esq. Hon. Memb. G. Soc.
	Specimens of Rocks from Scotland.	J. Macculloch, M.D. Memb. G. Soc.
	Geological specimens and Simple Minerals from Vesuvius.	Right Hon. Earl Compton, Memb. G. Soc.
	Horns of Deer found at Mundesley on the Coast of Norfolk.	Rev. W. Buckland, Memb. G. Soc.
	Pattern of a Mineralogical hammer.	J. Macculloch, M.D. Memb. G. Soc.
	Argillaceous Nodules containing ammonites, and called Salagram, worshipped by the Hindoos.	H. J. Colebrooke, Esq. Memb. G. Soc.
15.	Fossil Jaw of the Rhinoceros.	Henry Warburton, Esq. Memb. G. Soc.
	Agates found in the alluvial soil near North Allerton, on the Coast of Yorkshire.	Cooper Preston, Esq.
	Obsidian from the Isle of Ascension and Kerguelen's Land.	C. Stokes, Esq. Memb. G. Soc.
June 5.	Fossils from the Crag Pits.	Henry Warburton, Esq. Memb. G. Soc.
	Fossils from Feltrim Quarry near Dublin.	Geo. Cumberland, Esq. Hon. Memb. G. Soc.
	Crystallized Witherite.	Wm. Clayfield, Esq. Hon. Memb. G. Soc.
	Head of an Encrinite from near Bristol.	Mr. Miller.
	Fossil Pentacrinus from Lyme.	H. T. de la Beche, Esq. Memb. G. Soc.
	Fossil Animal found at Lyme.	....
	Specimen of a mass of Iron supposed to be meteoric, found near Florac in Lozere, by M. Henry.	M. Leman, For. Memb. G. Soc.
	Specimens from the neighbourhood of Bristol.	Henry Warburton, Esq. Memb. G. Soc.
	Specimens from the neighbourhood of Bristol.	Rev. W. Buckland, Memb. G. Soc.
	Ammonites from the lias at Lyme.	H. T. de la Beche, Memb. G. Soc.
	Specimens of a Granite Vein in slate in Cornwall.	....
	Vein of Granite in slate.	A. Majendie, Esq. Mem G. Soc.
	Specimens of Mica.	M. Leman, For. Memb. G. Soc.
	Specimen of the stone of Chateauroux, used in Lithography.	....
19.	Fragment of Bone of the Elephant found immediately above the London clay, in digging the Tunnel under Islington.	John Morgan, Esq. Memb. G. Soc.
	Specimens and Simple Minerals.	Henry Heuland, Esq. Memb. G. Soc.
	Specimens of simple Minerals.	Rev. Wm. Buckland, Memb. G. Soc.
	Fossils from the Chalk and Blue Marl.	Gideon Mantell, Esq. Memb. G. Soc.

1818.	SPECIMENS.	DONORS.
June 19.	Specimens from Guernsey and Jersey.	H. T. de la Beche, Esq. Memb. G. Soc.
	Flints from the Upper Chalk, Lewes.	Gideon Mantell, Esq. Memb. G. Soc.
	Specimens of Serpentine from Port Dalrymple, Van Diemen's Land.	C. Stokes, Esq. Memb. G. Soc.
	Black Naptha from the pits near Daulkie in Persia.	John Johnson, Esq.
	Varieties of Kieselsinter from the Geyser in Iceland, and of Calc-sinter from Carlsbad in Bohemia.	Major Peterson of Ratisbon.
	Specimen of a trunk of a Tree found at Morley Park Colliery.	Thomas Robinson, Esq.
	Specimen from the Tumuli on the edge of the Marshes regained from the Sea in the Parish of Tollesby, Essex.	Peter Ducane, Esq. Memb. G. Soc.
	Specimens of Clay Slate in contact with Granite, from Teign-Bridge, Devon.	H. T. de la Beche, Esq. Memb. G. Soc.
	Pyritous Fossil resembling the fin of the Balista.	....
	Fossil head of the Ichthyosaurus, shewing part of the eye.	....
	Variety of the Pentacrinite from the lias of Chidiock, Dorset.	....
	Fossil Fish exhibiting the scales, from Lyme.	....
	Part of the posterior paddle Bones of the Ichthyosaurus, from the lias at Lyme, Dorset.	....
	Fossil Tooth, or Palate, from the lias, Lyme, Dorset.	....
	Specimens from Guernsey and Jersey.	....
Nov. 6.	Fossil Wood from the Lias.	....
	Specimens illustrative of a comparison between the Limestone of Glyddon hill, near Much-Wenlock, in Shropshire, and that of Townhope, near Hereford.	Geo. Cumberland, Esq. Hon. Memb. G. Soc.
Dec. 4.	Fossil Lobster, from the Green Sand at Lyme Regis.	H. T. de la Beche, Esq. Memb. G. Soc.
	Various Fossils and Specimens from Bavaria, the Tyrol, &c.	Henry Heuland, Esq. For. Sec. G. Soc.
	Specimens of English Strata.	Rev. W. Buckland, Memb. G. Soc.
	Greywacke slate with Terebratulæ, near Wales.	H. T. Colebrooke, Esq. Memb. G. Soc.
	Fossils from the Chalk, near Lewes, Sussex.	Geo. Cumberland, Esq. Hon. Memb. G. Soc.
	Fossil Balanus from Turin.	Hon. H. G. Bennet, Memb. G. Soc.
	Fossil Shells found in digging a well in Colonel Marshall's garden, Madras.	Wm. Babington, M.D. Memb. G. Soc.
	Specimens from the East Indies.	....
	Arragonite from Somersetshire.	Robert Anstice, Esq. Memb. G. Soc.
	Specimens from Russia.	Hon. W. T. H. Fox Strangways, Mem. G. Soc.
14.	Tufa formed on moss, Oxfordshire.	Rev. Wm. Buckland, V. P. G. Soc.

1818.	SPECIMENS.	DONORS.
Dec. 14.	Specimens of Simple Minerals and Rocks.	H. J. Brooke, Esq. Sec. Geo. Soc.
	Two specimens of Stone for Lithography.	C. Stokes, Esq. Memb. G. Soc.
	Fossils from Chobham.	Right Hon. Earl Compton, Memb. G. Soc.
22.	Chert of the Green Sand passing into Heliotrope.	Rev. Wm. Buckland, V. P. G. Soc.
30.	Carbonate of Barytes.	Thomas Dugard, M.D. Memb. G. Soc.
1819.		
Jan. 4.	Rocks from Baffin's Bay, collected by Capt. Ross.	J. Macculloch, M.D. Memb. G. Soc.
	Fossils from Altofts, near Wakefield.	G. Hewitt, Esq. Memb. G. Soc.
	Specimens from the East Indies.	Dr. Adams, Calcutta.
9.	Specimens of the Granite veins traversing the Schist, Laurren hill, Scotland.	Henry Warburton, Esq. Memb. G. Soc.
20.	Stalactitic Arragonite from the grotto of Antiparos.	Rev. J. Holme, Memb. G. Soc.
	Specimens of Chalk and Mulatto Stone altered by Whin Dykes, from Belfast in Ireland.	....
	Specimens from Cumberland.	....
	Fossil Wood from Kamtschatka	W. Dansey, Esq. Mem. G. Soc.
Feb. 1.	Fossils from the Mountain Limestone near Bristol.	C. Stokes, Esq. Memb. G. Soc.
5.	Fossils from the Highgate tunnel.	Arthur Aikin, Esq. Memb. G. Soc.
20.	Fossils from the copper mines at Chessy, and Ammonites from the Ashantee coast.	Capt. Marryat, Memb. G. Soc.
23.	Basalt from Monte Gloso, near Bassano.	Joseph Marryat, Esq. Memb. G. Soc.
26.	Anthracite in trap-tuff, Calton hill, and shorl from Rubislaw, Aberdeenshire.	Robert Ferguson, Esq. Memb. G. Soc.
Mar. 1.	Specimens of the Dudley limestone with Entomolites, and black oxide of Manganese.	Samuel Parkes, Esq. Memb. G. Soc.
19.	Crystallized Sulphate of Soda with Magnesia, from Catalayud in Spain.	Sign. Parga of Madrid.
	Fossils from the Chalk and Green Sand.	Miss Benett.
21.	Specimens of Fluor, from Cornwall.	J. T. Cooper, Esq. Memb. G. Soc.
23.	Ancient tool called a Noger, formerly used in working the mines of Derbyshire.	J. Mawe, Esq.
28.	Specimens of Rocks from Scotland.	J. Macculloch, M.D. Memb. G. Soc.
April 2.	Calcareous Stalactites.	Mich. Bland, Esq. Memb. G. Soc.
16.	Recent freshwater Shells.	Joseph Marryat, Junr. Esq. Memb. G. Soc.
	Recent freshwater and marine Shells.	Henry James Brooke, Esq. Memb. G. Soc.
	Specimens of Wood and Stream Tin.	....
	Cavernous Quartz, incrusted with carbonate of iron and manganese.	Dr. Leach.
26.	Arragonite, found in the inferior oolite at Osmington.	Rev. W. Buckland, Memb. G. Soc.

1819.	SPECIMENS.	DONORS.
May 3.	Specimens from the East Indies.	H. T. Colebroke, Esq. Memb. G. Soc.
4.	Fossils from the Chalk.	Capt. Vetch, Memb. G. Soc.
7.	Recent Shells.	Capt. Marryat, Memb. G. Soc.
14.	Orbicular sienite of Corsica.	Henry Heuland, Esq. For. Sec. G. Soc.
	Graphite in Carbonate of Lime.	Professor Weiss near Berlin, For. Memb. G. Soc.
	Specimen of Peperino.	Wm. Somerville, M.D. Memb. G. S.
24.	Specimens from Glamorganshire.	Rev. J. M. Traherne, Memb. G. Soc.
	Flint and Fossil Shell from Isleham gravel pits, near Harwich.	Rev. J. Holme, Memb. G. Soc.
June 6.	Specimens from Cambridgeshire.	Francis Lunn, Esq.
	Specimens from Italy and Ceylon.	Wm. Somerville, M.D. Memb. G. Soc.
	Specimens from the environs of Built in Brecknockshire.	H. T. de la Beche, Esq. Memb. G. Soc.
	Specimens from Shropshire.	Hon. Henry G. Bennet, Memb. G. Soc.
	Specimen of Napoleonite.	Right Hon. Earl Compton, Memb. G. Soc. and Hon. H. G. Bennet, Memb. G. Soc.
	Minerals from Ischia.	Right Hon. Earl Compton, Memb. G. Soc.
	Fossil Fish in Chalk.	Miss Bennet.
	Resin from the blue clay at Hampstead.	Henry Warburton, Esq. Memb. G. Soc.
July 24.	Cast of an Ammonite in Flint.	J. Michel, Esq. Lieut. Roy. Eng.
25.	Specimens of the Tottenhoe stone.	C. Hanmer, Esq. Memb. G. Soc.
Aug. 8.	Fossil Fish from Monte Bolca.	Right Hon. Earl Compton, Memb. G. Soc.
	Selenite from Bex in Switzerland.	William Marshall, Esq. Memb. G. Soc.
	Siliceous Fossil Wood impregnated with copper, from the Oural mountains.	Mr. Lukin.
Sept. 10.	Specimens from the neighbourhood of Moscow.	Hon. W. T. H. Fox Strangways, Mem. G. Soc.
11.	Specimens of the Strata and Fossils of the island of Antigua.	Nich. Nugent, M.D. Memb. G. Soc.
12.	Fossils from the chalk and ferruginous sand in Sussex.	Gid. Mantell, Esq. Memb. G. Soc.
18.	Specimens from the Isle of Man.	J. Henslow, Esq. Memb. G. Soc.
Oct. 8.	Specimens from the East Indies.	Col. Hardwicke, F.R.S.
	Specimens of Rocks from the East Indies.	Dr. Adams, Calcutta.
29.	Specimens of the Tortoise Encrinite.	Gid. Mantell, Esq. Memb. G. Soc.
	Specimens from China, Corea, and Loo Choo.	Capt. Basil Hall, Mem. G. Soc.

1819.	SPECIMENS.	DONORS.
Oct. 29.	Specimens from Ireland, and Anticosta Island North America.	Right. Hon. Earl Compton, Memb. G. Soc.
	Specimens from Chiltern downs.	Miss Benett.
	Specimens from the East Indies.	H. T. Colebrooke, Esq. V. P. G. Soc.
Nov. 6.	Specimens of Rocks from Sweden.	S. Kent, Esq. Memb. G. Soc.
	Specimens of Piperino impressed with Shells, found near Albano.	W. Somerville, M.D. Memb. G. Soc.
Dec. 1.	Specimens from Cornwall.	Frederick Moysey, Esq. Memb. G. Soc.
2.	Specimens of Plastic Clay from Norden clay pits, near Corfe castle.	Benj. Fayle, Esq. Memb. G. Soc.
10.	Specimens from the Island of Mull.	Right Hon. Earl Compton, Pres. G. Soc.
30.	Specimens from Newfoundland.	J. Macculloch, M.D. Memb. G. Soc.
1820.		
Jan. 6.	Specimens of a variety of Limestone from Staffordshire called Curl, in illustration of a paper on the subject.	Rev. James Yates, Memb. G. Soc.
	Nautilus from Lyme Regis, Dorset.	C. Stokes, Esq. Memb. G. Soc.
8.	Specimens of Simple Minerals and Fossils.	H. J. Brooke, Esq. Memb. G. Soc.
Feb. 7.	Slickenside of Blende from the Crumford moor Mine, near Matlock.	Professor Cumming, Memb. G. Soc.
14.	Recent Shells.	G. B. Greenough, Esq. Memb. G. Soc.
15.	Various British and Foreign Geological specimens.	H. Warburton, Esq. Memb. G. Soc.
Mar. 1.	Various British and Foreign Geological specimens.	G. B. Greenough, Esq. Memb. G. Soc.
4.	Specimens of Septaria, from Harwich, and of Chert from the limestone of Warnell Fell.	Rev. J. Holme, Memb. G. Soc.
	Carbonate of Lime from Strontian.	....
	Lepidolite from Dalmally.	....
	Crystals of pure Alumine from Mexico.	....
	Black Iron Ore from Mexico.	....
	A Horn found in a barrow near the Red Lodge, 5½ miles from Newmarket.	....
	Native Carbonate of Zinc from Lord Ribbesdale's mines, Yorkshire.	John Taylor, Esq. Treas. G. Soc.
	Specimens from Ceylon.	Sir Alexander Johnson.
	Specimens of calcareous Spar and yellow Copper Ore, from the Ecton mine.	His Grace the Duke of Devonshire, Mem. G. Soc.
	Specimen of a Fossil Inoceramus, shewing the hinge.	C. Stokes, Esq. Memb. G. Soc.
	Ammonites from the upper Chalk.	Capt. Vetch.
17.	Specimens from Devonshire.	C. Worthington, Esq. Memb. G. Soc.
April 5.	Specimens from the Alps.	H. T. De la Beche, Esq. Memb. G. Soc.
12.	Specimens of English Strata.	H. J. Brooke, Esq. Memb. G. Soc.
14.	Fossils from the Plymouth Limestone.	Rev. Richard Hennah.

1820.	SPECIMENS.	DONORS.
April 21.	Specimens from Cooch Behar, in Bengal.	H. T. Colebrooke, Esq. V. P. G. Soc.
May 1.	Mica from Arkangel.	Richard Knight, Esq. Memb. G. Soc.
	Fossils and recent Shells.	Miss Benett.
5.	Specimens of Lava from Vesuvius.	Ashhurst Majendie, Esq. Memb. G. Soc.
	A Joint of Columnar Basalt from Carsaig in Mull.	Right Hon. Earl Compton, Memb. G. Soc.
10.	A Skeleton of the Proteosaurus found at Lyme Regis; and a Head of another.	Henry Warburton, Esq. Memb. G. Soc.
	Specimen of English Strata.	C. Stokes, Esq. Memb. G. Soc.
	Specimen of Dudley Limestone, with an Entomolite.	Hon. H. G. Bennet, Memb. G. Soc.
	Micaceous Iron Ore from Lustleigh, Devon.	C. Worthington, Esq. Memb. G. Soc.
	Portion of a silicified Tree from the green sand at Sidmouth.	....
24.	Specimens illustrative of a Limestone vein at Cette near Montpelier.	C. Daubeny, M.D. Memb. G. Soc.
28.	Specimen of foliated white Antimony.	C. Stokes, Esq. Memb. G. Soc.
	Specimen of the Black Rock near Dublin, with an Entomolithus.	A. Anstice, Esq. Memb. G. Soc.
June 16.	Specimens of Fossils and Simple Minerals from Russia.	Sir Alex. Crichton, Memb. G. Soc.
	Specimens from the top of Snowdon with fossil Shells.	F. Clissold, Esq.
	Specimen of flexible Sandstone from Brazil.	Hon. W. T. H. Fox Strangways, Memb. G. Soc.
	Specimens of Maricanites from Kamtschatka.	....
	Specimens of Simple Minerals.	Dr. Rohatch of Freyberg.
	Specimen of Chromate of Iron in a matrix of talc, from North America.	Arthur Aikin, Esq. Memb. G. Soc.
Aug. 3.	Slab of elastic Marble from North America, and specimens of vegetable Impressions from the Coal near Chatley, Somerset.	T. Meade, Esq. Hon. Memb. G. Soc.
	Cupreous silicate of Zinc, from Matlock.	Mr. Gilbert of Matlock.
	Fossil in Flint, from Russia.	Hon. W. T. H. Fox Strangways, Mem. G. Soc.
	Fossils in the Flints of the Chalk.	Capt. Vetch, Memb. G. Soc.
	Fossil Shell from the Lias.	Mr. C. Brooke.
	Specimens of Lead Ore in Trap.	C. Stokes, Esq. Memb. G. Soc.
Nov. 8.	Calcareous Spar from the Chalk in Sussex.	F. Sargent, Esq. Memb. G. Soc.
9.	Specimens of Rocks from Penang and Singapoor, in India, collected by Mr. Wm. Jack.	H. T. Colebrooke, Esq. V. P. G. Soc.
	Specimen of Peacock Coal from the neighbourhood of the river Bury, Glamorganshire.	Right Hon. Sir John Nicholl, Memb. G. Soc.
	Fossils from English Strata.	Lieut. Terry, Memb. G. Soc.
	Fossils from the Mountain Limestone.	C. Stokes, Esq. Memb. G. Soc.
	Fossil Fish from the Lias at Lyme Regis.	....
	Fossil Fish from Monte Bolca.	....
	Fossil Vegetable from the freshwater formation, Isle of Wight.	T. Webster, Esq. Sec. G. Soc.

1820.	SPECIMENS.	DONORS.
	Specimen of Rocks from Scilly Island and Ireland.	Wm. Babington, M.D. Memb. G. Soc.
	Skull of a Rhinoceros found at King's Newnam, near Lawford church, in Warwickshire.	Rev. W. Buckland, Memb. G. Soc.
	Fossil Fish from Monte Bolca.	F. Chantrey, Esq. Memb. G. Soc.
	Native Copper on sulphate of barytes, Parys mine.	T. R. Underwood, Esq.
	Specimens from the Himala mountains, collected by Lieut. A. Gerard.	H. T. Colebrooke, Esq. V. P. G. Soc.
Dec. 10.	A crystal of Corundum.	Mr. Mawe.
11.	Specimen of Mosaic from India.	Wm. Babington, M.D. Memb. G. Soc.
	Specimen of recent Coral, enclosed in compact Limestone.	C. Stokes, Esq. Memb. G. Soc.
	Specimen of Copper Ore from the Calley copper mine, in Scotland.	John Taylor, Esq. Treas. G. Soc.
15.	Axinite from Botallack mine, Cornwall, and Quartz from Beeralston, Devonshire.	Henry Heuland, Esq. For. Sec. G. Soc.
	Specimens from Melville Island in the Polar Sea, collected by Lieut. Liddon.	A. B. Granville, M.D. Memb. G. Soc.
19.	Specimens of Serpentine and Diallage Rock, from Shetland.	J. Macculloch, M.D. Memb. G. Soc.
	Specimens of the Lyas and its fossils, from Lyme Regis.	H. T. De la Beche, Esq. Memb. G. Soc.
	Specimens from Switzerland and the Rhine.	....
	Polished specimen of Calcaire grossiere with Nummulites, Verona.	Rev. W. Buckland, Memb. G. Soc.
	A collection of Rocks from the Swiss Alps.	M. Ch. Lardi, of Lausanne, For. Memb. G. Soc.
	A Map of the Country in which the above specimens were collected, with their localities inserted.	T. Webster, Esq. Sec. G. Soc.
	Specimen from the neighbourhood of Glasgow.	Right Hon. Earl Compton, Pres. G. Soc.
1821.		
Feb. 15.	Capillary red oxide of Copper, and Schorl in Quartz, Cornwall.	John Taylor, Esq. Memb. G. Soc.
Mar. 2.	Specimens of Gypsum hardened by heat.	James Vine, Esq. Treas. G. Soc.
	Recent Echinus.	Hon. W. T. H. Fox Strangways, Memb. G. Soc.
	Siliceous casts of Perforations in Belemmites, from the Chalk Quarries of Larne, in Antrim, Ireland.	Right Hon. Earl Compton, Pres. G. Soc.
12.	Polished specimen of Gypsum from the Isle of Purbeck.	Hon. W. T. H. Fox Strangways, Memb. G. Soc.
	Specimens of Rocks from the mines of Chessy St. Bel, and from Vienne in Dauphiny.	M. Mariano de Rivero.
	Specimen of Fibrous coal, South Wales.	J. T. Guest, Esq. Memb. G. Soc.
	Specimens of Magnesian limestone and other English strata.	William Danby, Esq.
22.	Fossils from English Strata, and recent Shells.	Miss Benett.

1821.	SPECIMENS.	DONORS.
Mar. 22.	Specimen of Lyas Marble from Bridport.	Hon W. T. H. Fox Strangways, Memb. G.Soc.
30.	Specimens of Pargasites.	....
April 2.	Chert from the Mountain Limestone, Halkin, Fintshire.	John Taylor, Esq. Memb. G. Soc.
	Sulphate of Barytes and a fragment of a Septarium.	A. Majendie, Esq. Memb. G. Soc.
	Fossil Shells from Grignion.	H. J. Brooke, Esq. Memb. G. Soc.
May 2.	Specimens of Tin Ore and Porcelain Clay, from Ailsbarrow mine, Dartmoor.	J. H. Deacon, Esq. Memb. G. Soc.
	Specimens from Scotland.	Geo. Berry, Esq. Edinburgh.
	Fossil Shells from Plaistow near Bromley.	J. W. Lubbock, Esq.
	Specimens from Van Dieman's Land.	C. Stokes, Esq. Memb. G.Soc.
	Fossils from the Chalk in the Parish of Shiere.	Right Hon. Earl Compton, Pres. G. Soc.
	Nodule of Chalcedony in trap.	J. H. Deacon, Esq. Memb. G. Soc.
	Specimens from the neighbourhood of Bristol.	William Danby, Esq.
	Specimens of Mountain and Magnesian limestone.	....
May 14.	Specimens from Stromboli.	John Sanders, Esq. Memb. G. Soc.
	Ammonite from Lyme Regis.	Rev. W. Buckland, Memb. G. Soc.
June 20.	Specimens of Simple Minerals from Norway.	F. Chantrey, Esq. Memb. G. Soc.
5.	Specimens of Paludina Ventricosa (Leach).	J. S. Henslow, Esq. Memb. G. Soc.
9.	Fossils from Hordle Cliff, Hampshire.	Miss Salisbury.
	Specimens from New Holland and Van Dieman's Land.	C. Stokes, Esq. Mem. G. Soc.

1821.	CABINETS.	
	40 new Cabinets to contain the Specimens presented to the Society	Purchased out of the fund for procuring Cabinets, Books and Maps.

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EXPLANATION OF THE PLATES.

✓PLATE 1.

In illustration of Mr. W. Phillips's paper on the Chalk Cliffs near Dover, &c.

Fig. 1. Is a sketch of the Chalk Cliffs between Deal and Folkstone. It must however, be noticed that in this sketch, the height of the cliffs is too great in proportion to their length, the dip of the strata being somewhat less than one degree. If reduced to their actual proportionate height, it would scarcely exceed one-fourth that of the sketch.

Fig. 2. Is a view of the Chalk Cliffs forming Cape Blanc Nez on the coast of France, opposite to Dover. It will be observed that the beds of Fig. 1 & 2 seem to dip in opposite directions, but if the spectator be supposed to be on the sea between the two coasts, he will look nearly north while viewing the Cliffs near Dover, but nearly south when viewing Cape Blanc Nez. The dip in both is towards the east.

Fig. 3. Represents an Inoceramus from the Chalk with few flints near Dover; it is described at page 55, by Mr. Parkinson, who has named it Inoceramus Lamarckii.

Figs. 4. & 5. Are Inocerami from the blue marle near Folkstone; they are described by Mr. Parkinson at page 59, as Inoceramus concentricus, and Inoceramus sulcatus.

✓PLATES 2, 3, 4, 5.

In illustration of Mr. Cumberland's paper.

Encrini and Pentacrini found in the neighbourhood of Bristol.

EXPLANATION OF THE PLATES.

✓PLATES 6, 7, 8, 9, 10, 11, 12, 13, 14, 15.

In Illustration of Mr. Weaver's paper on the Geological relations of the East of Ireland.

PLATE 6 contains,

No. 1. View of the small range of hills near Kildare, taken from the Curragh, about 1½ mile from the town. The range is elevated from 200 to 300 feet above the surrounding country.

No. 2. Circular view from the summit of Dunmurry hill, one of the above mentioned range, from which may be perceived a great part of the field of inquiry; the whole range of mountains on the east being presented to observation, from the vicinity of Dublin on the north to Brandon hill on the south, in which direction the prospect is terminated by the coal country, and on the west by the Slieve Bloom mountains; while to the north the view expands over the flat central part of Ireland, interrupted in that quarter only by Croghan hill in the King's county, by the straggling hills of Westmeath, and the more extended range of the Cavan hills beyond.

PLATE 7 contains,

No. 3. A view taken from the western borders of the Killenaule coal district, above Littlefield, extending from the Slieve Bloom on the north, through the Devil's Bit, to the Bilboa mountains on the south; and more immediately south of the spectator are seen the last portions of the Killenaule coal district, spreading towards Cashel, with a part of the Gaultees mountains beyond.

No. 4. A view from the northern brow of Pallis hill, in the county of Limerick, exhibiting the Bilboa mountains on the north, with the mountains of the county of Clare beyond the Shannon on the west, and Slievenaman on the east.

No. 5. A view from the south-eastern side of the same hill, of the noble range of the Gaultees mountains, stretching from Caher on the east towards Charleville on the west; the fore ground being partly occupied by the trap range of Knock Rua, Knock Dirk, and Kilteely hills.

EXPLANATION OF THE PLATES.

No. 6. A view taken from the south-eastern face of the Gaultees mountains, above Caher, which extends from Slievenaman on the north of the Suire, through the picturesque ranges of the Monavoullagh and Knockmildown mountains on the south, which occupy the tract situated between the rivers Suire and Blackwater.

PLATE 8 contains,

No. 7. A circular view from the summit of Cronebane hill, which extends to Blackstairs on the south, to Djouce and Great Sugar Loaf on the north, to Lugnaquilla on the west, and to the sea on the east.

No. 8. A view taken from the southern brow of the hill on the eastern side of the Scalp, extending from Shank hill and the sea on the east, through Bray Head, the two Sugar Loaves, and Djouce mountain to Glencree, and Glencullen on the west.

No. 9. A view taken from the northern peak of Little Sugar Loaf, extending from Maulin hill on the south-west, through Glencree, Glencullen, the Scalp, and Shank hill to Dalkey Head on the north-east, with the bay of Dublin, Howth, and part of the island of Lambay beyond them to the north.

PLATE 9 contains,

No. 10. A view of the northern aspect of the mountains near Dublin, taken from the Grand Canal, near the Twelfth Lock.

No. 11, *No.* 12, *No.* 13, and *No.* 14. Separate views of Howth, and of the isles of Lambay, and Ireland's Eye.

PLATE 10 contains,

No. 15. A view taken from Eagle hill, of the mountain range extending westward from Lugnaquilla.

No. 16. A view of Cadeen from Kilranela hill.

No. 17. A view of the mountains around the glen of Imale, taken from Bushfield, nearly in its center.

No. 18. A circular view from Coolattin hill, in the barony of Shillelagh.

EXPLANATION OF THE PLATES.

Plate 11.

A Map, in illustration of the geology of Croghan Kinshela mountain, and of the works which were carried on there, under the auspices of Government.

Plate 12.

Plan and Sections of the Copper Mines in Cronebane and Tigrony, in elucidation of the metalliferous relations of that district.

Plate 13 contains,

Views copied from nature.

Fig. 1. 2 3. & 4. Beds and veins of granite in mica-slate.

Fig. 5. Fragments of mica-slate in a metalliferous vein.

Fig. 6. & 7. Horizontal plan of contemporaneous veins in transition greywacké.

Fig. 8. Vertical section of contemporaneous veins in the same rock.

Fig. 9. & 10. Pebbles of limestone in transition greywacké slate.

Fig. 11. & 12. Veins of breccia, traversing flœtz limestone and slate-clay.

Plate 14 contains,

SECTIONS.

No. 1. Through the Castlecomer coal district, from the Nore on the west to the Barrow on the east.

No. 2. From the Barrow on the west to the summit of Lugnaquilla on the east.

No. 3. From the summit of Lugnaquilla on the west, to the sea at Arklow on the east.

In the last two sections, mountains are in some cases projected on the line of section, which stand not immediately in the line.

No. 4. Through the Killenaule coal district.

Plate 15.

Map of the Tract.

PLATE 16.

In illustration of Mr. W. Phillips's paper.

Primitive Crystal of the Sulphate of Barytes and its modifications.

EXPLANATION OF THE PLATES

CONTINUED.

PLATE 17.

Map of the river Voxa and the Lake Souvando, with the surrounding country.

PLATE 18.

Fig. 1. Section across the river Voxa at the falls of Imatra.

Fig. 2. Plan of the river Voxa, at the falls of Imatra; on the banks are the boulders described at page 341.

PLATE 19.

Fig. 1. Basaltic dykes in the Isle of Mull, near Carsaig; described page 370.

Fig. 2. Represents Stona Buach, or the promontory of the Goats, Isle of Mull. The upper part consists of columnar basalt, which rests on irregular strata of limestone and green sandstone. See page 372.

PLATE 20.

Natural perforations in basaltic rocks in the Isle of Mull. The nearest is called Bidda vich Re Lochlin, or the promontory of the son of the King of Norway. It is pierced through a detached rock, and the arch is about 70 feet high; on the top of the rock is a row of apparently single basaltic columns, as if it were a columnar dyke. Two of these columns stand by themselves. The base of this rock is green sand in coarse grains. The farthest perforation is called Uam-will, or the pierced Cave. It is about 60 feet high, and between 50 and 60 feet broad. The rock which it pierces is basalt, resting on green sand. Over the arch is a stratum of basaltic columns. See page 373.

EXPLANATION OF THE PLATES.

PLATE 21.

This represents the view looking out from the most distant of the arched rocks in Plate 21.

PLATE 22.

Fig. 1. Represents a new Pentacrinus found lately at Lyme Regis, considerably resembling that called by Mr. Parkinson the Briarean.

Fig. 2. Is the part from which the arms spring.

Fig. 3. Represents the lower part of the stem, which is so nearly circular, that at first it was thought to be an encrinus.

Fig. 4. Part of the stem towards the head, exhibiting decidedly the pentagonal form. See 379.

PLATE 23.

Fig. 1. A new and peculiar species of Encrinus. See page 380.

Fig. 2, 3, 4, & 5, Represent a separated Pelvis belonging to the Briarean Pentacrinus. See page 380.

PLATE 24.

Map of part of the course of the brook Pulcovca, near Petersburgh.

PLATE 25.

Views on the brook Pulcovca, coloured geologically.

PLATE 26.

Fig. 1. Landslip of the dark green clay on the right bank of the Pulcovca, marked *a* in the plan and section. See page 390 and 391.

Fig. 2. View looking down the Pulcovca. *x* and *y* are dykes in the limestone rock, filled with diluvium. These plates represent the natural colours of the rocks. See page 390.

EXPLANATION OF THE PLATES.

PLATE 27.

Fig. 1. View of the Pulcovca coloured geologically. The colours correspond with those in plate 25. See page 390.

Fig. 2 & 3. Two Sections of the Pulcovca outlier.

Fig. 4. Section of the Strata along the course of the Pulcovca, to explain the relative situation of the disturbed beds.

PLATE 28.

Map of the environs of St. Petersburg.

PLATE 29.

Fig. 1. Section of the heights of Crasno Celo, near St. Petersburg, from N.E. to S.W. See page 401.

Fig. 2. Section of the hills on the east side of the Ligovca. See page 401.

Fig. 3. Clay veins on the Coirovca. See page 407.

Fig. 4. Represents a Section of the country on the right bank of the Neva. See page 414.

PLATE 30.

The upper part of the valley of the Ligovca, coloured geologically. See page 429.

PLATE 31.

Fig. 1. View near Gertova on the right bank of the Tosna. See page 447.

PLATE 32.

Map of the Island of Antigua, coloured geologically. See Dr. Nugent's paper. page 459.

PLATE 33.

Sections of the Island of Antigua, coloured geologically; the directions in which the Sections are taken are marked on the map, plate 32.

EXPLANATION OF THE PLATES.

PLATE 34.

Views in the Island of Antigua, coloured geologically. See Dr. Nugent's paper on Antigua, page 459.

PLATE 35.

Map and Sections of the Isle of Man, coloured geologically.

Fig. 1. represents a Section of a bed of greywacke occuring in clay-slate on the north part of Douglas Bay, perpendicular to the direction of the strata. See page 490.

Fig. 2. is a Section of the same place parallel to the direction of the strata.

Fig. 3. Beds of greywake intersecting the clay-slate at a quarry at Port Eshee. See page 490.

Fig. 4. Trap dykes in the limestone between Pool-vash and Scarlet Point.

Fig. 5. represents a Section of a portion of gneiss near the Dun. See page 489.

Fig. 6. is a Section from Pool-vash to Scarlet point. See page 497.

PLATE 36.

Geological Map of the Lickey Hill in Worcestershire. See page 506.

PLATE 37.

Map of the vale of Evenlode, Thames, &c. See page 516.

PLATE 38.

Fig. 1. Section across the N.E. part of Yorkshire, coloured geologically. See page 545.

Fig. 2, 3, 4. Sections of parts of the Coast in the NE. of Yorkshire.

Fig. 5. Section of the country from Merstham to Nutfield in Surry; to explain the situation of the Reygate fire stone, and Fuller's earth. The scale of the heights is much greater than that of the lengths. See page 352.

Fig. 6. exhibits the manner in which the substance called Curl-stone in Staffordshire occurs, attached to the under side of an iron-stone bed. See page 375.

EXPLANATION OF THE PLATES.

PLATE 39.

Vitreous sand-tubes found at Drigg in Cumberland.

Fig. 1. represents a portion much contorted, of the natural size.

Fig. 2. is a small ramification.

Fig. 3. exhibits the lower part where it struck a granite pebble.

Fig. 4. represents a portion of the thickest part of these tubes drawn to the full size.

Fig. 5. a portion that is forked.

Fig. 6, 7, 8, 9. Sections of various parts of the tubes, taken across.

PLATE 40.

Osteology of the head of the Ichthyosaurus.

Fig. 1 to 8. Transverse sections of the left lower jaw, shewing its composition; figures 1 and 3, also take in the upper jaws.

Fig. 9. Side view of the head.

Fig. 10. Lower jaws seen from beneath.

Fig. 11. Head seen from above.

Fig. 12. Roof of the mouth.

PLATE 41.

Fig. 1 to 11. Vertebræ of the Plesiosaurus.

Fig. 12 & 13. Vertebræ of the Ichthyosaurus.

PLATE 42.

Fig. 1 & 2. Fragments of the paddle of the Plesiosaurus.

Fig. 3. Scapula, coracoid bones, humerus, radius and ulna, of the Plesiosaurus.

Fig. 4. Humerus, radius and ulna, seen in another point of view, with the carpal bones attached.

Fig. 5. The whole paddle conjecturally restored.

Fig. 6. One of the ribs.

All the figures, except 5, are half the size of the original.

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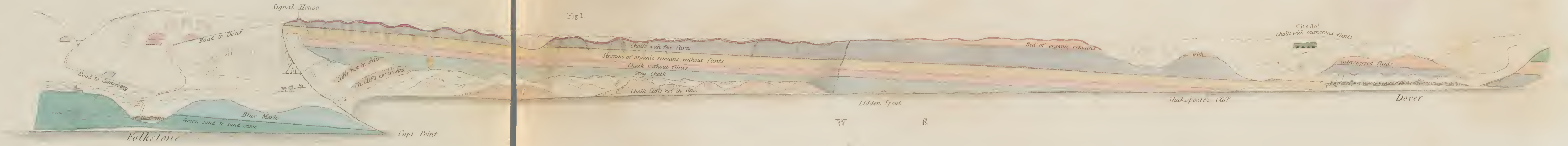

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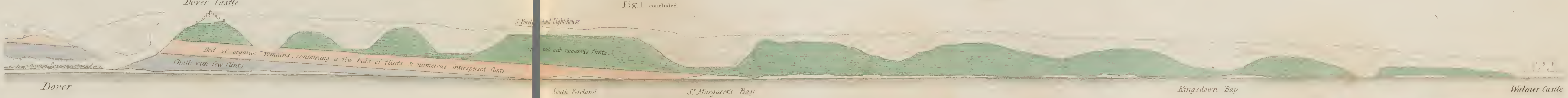

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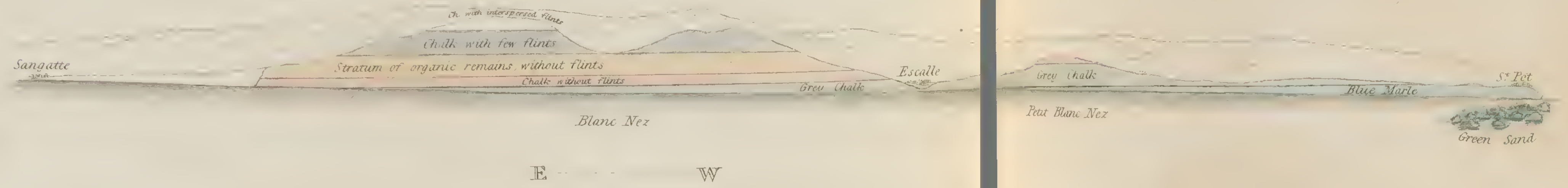

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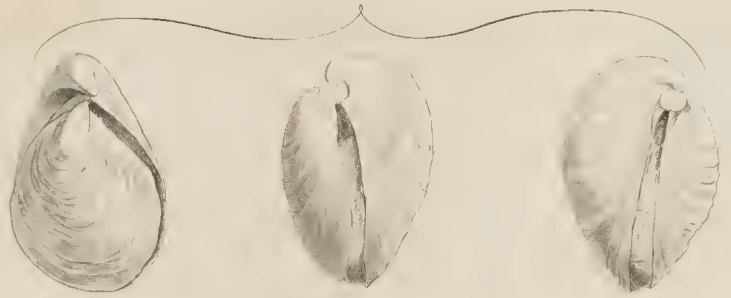

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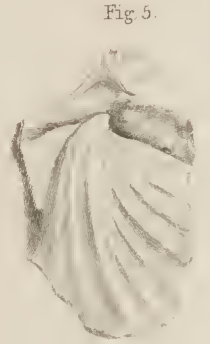

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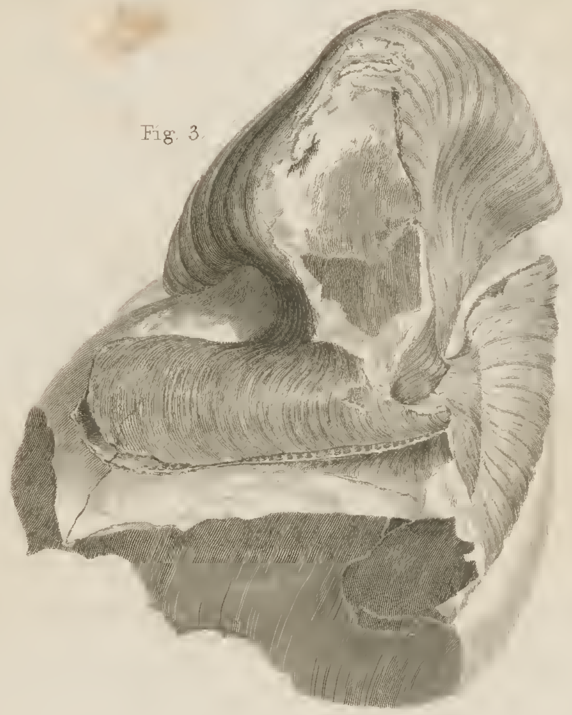

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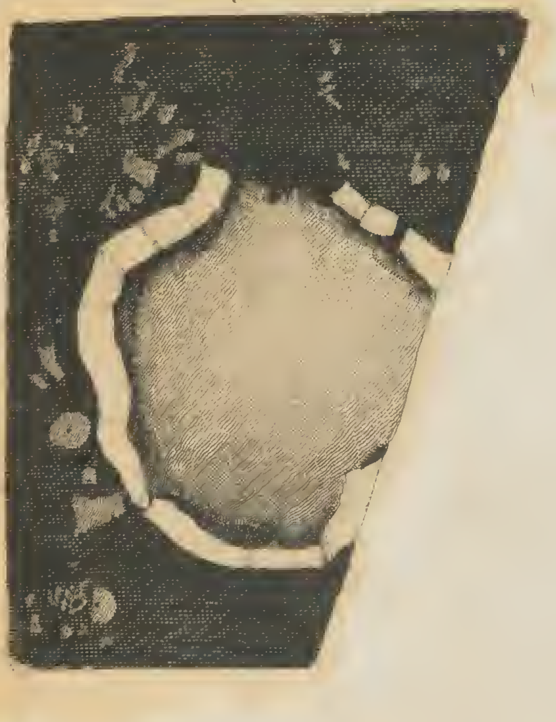

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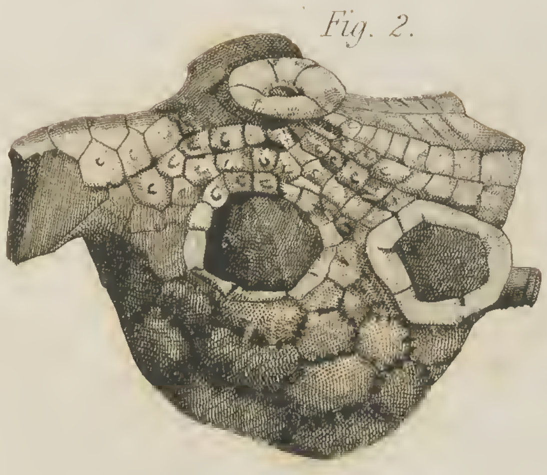

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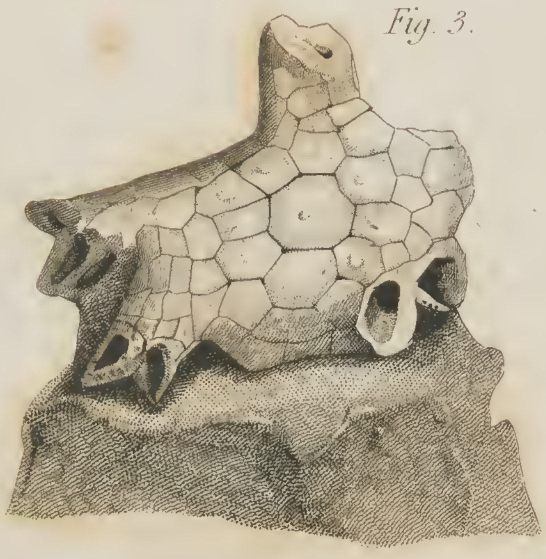

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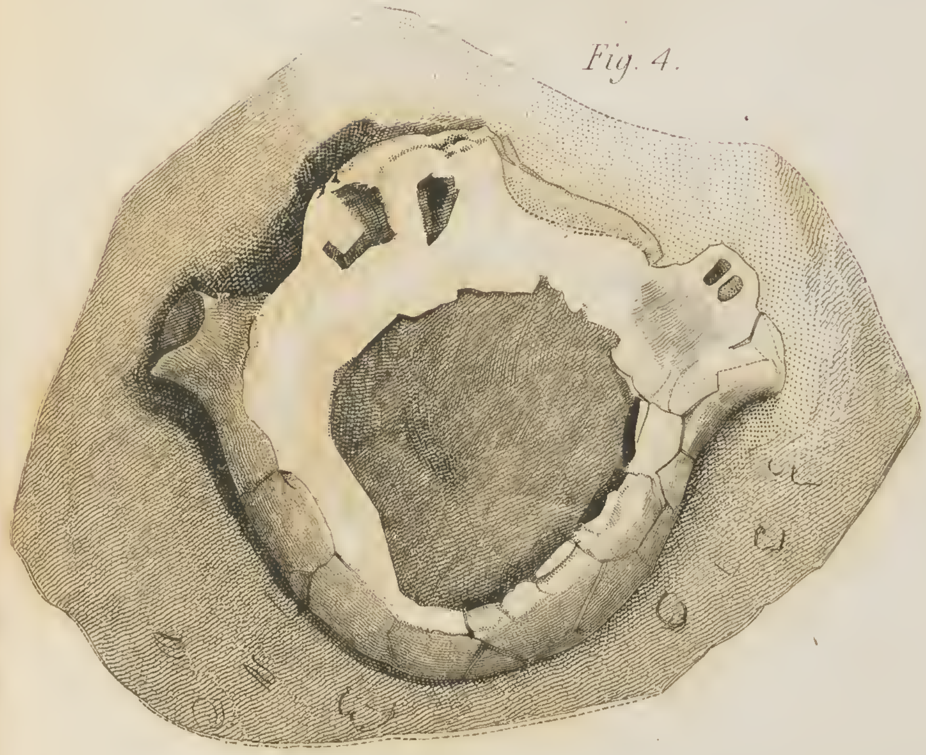

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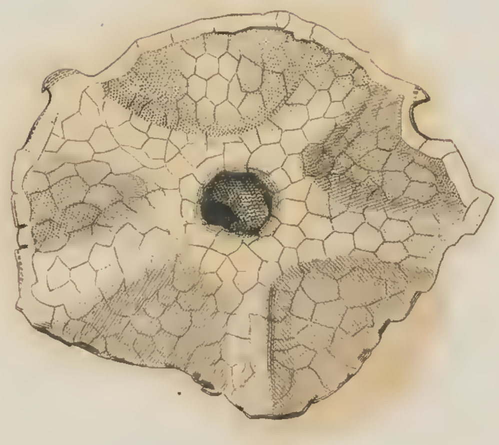

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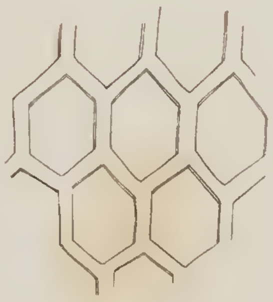

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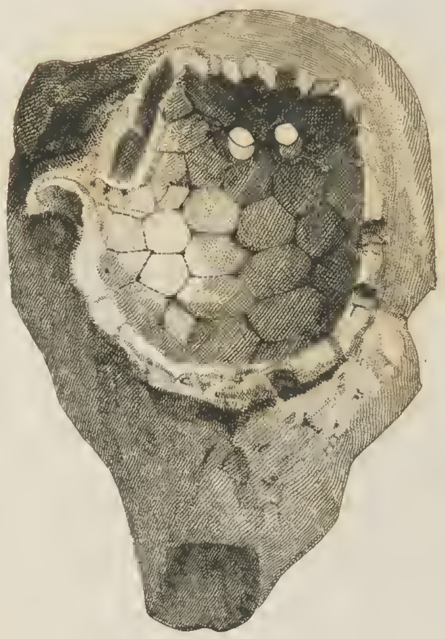

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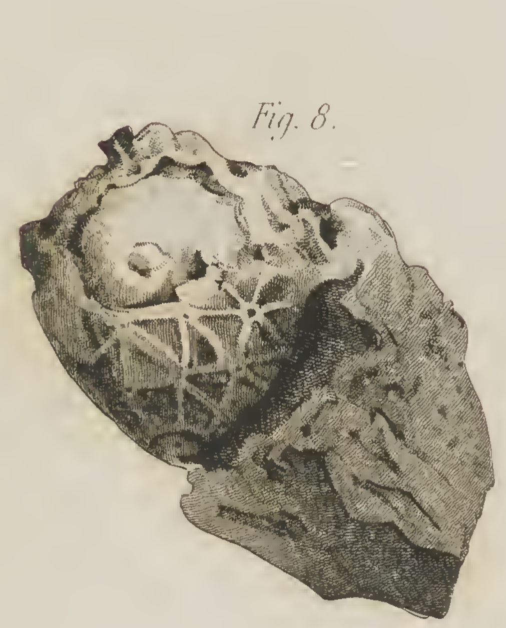

Encrini found near Bristol.

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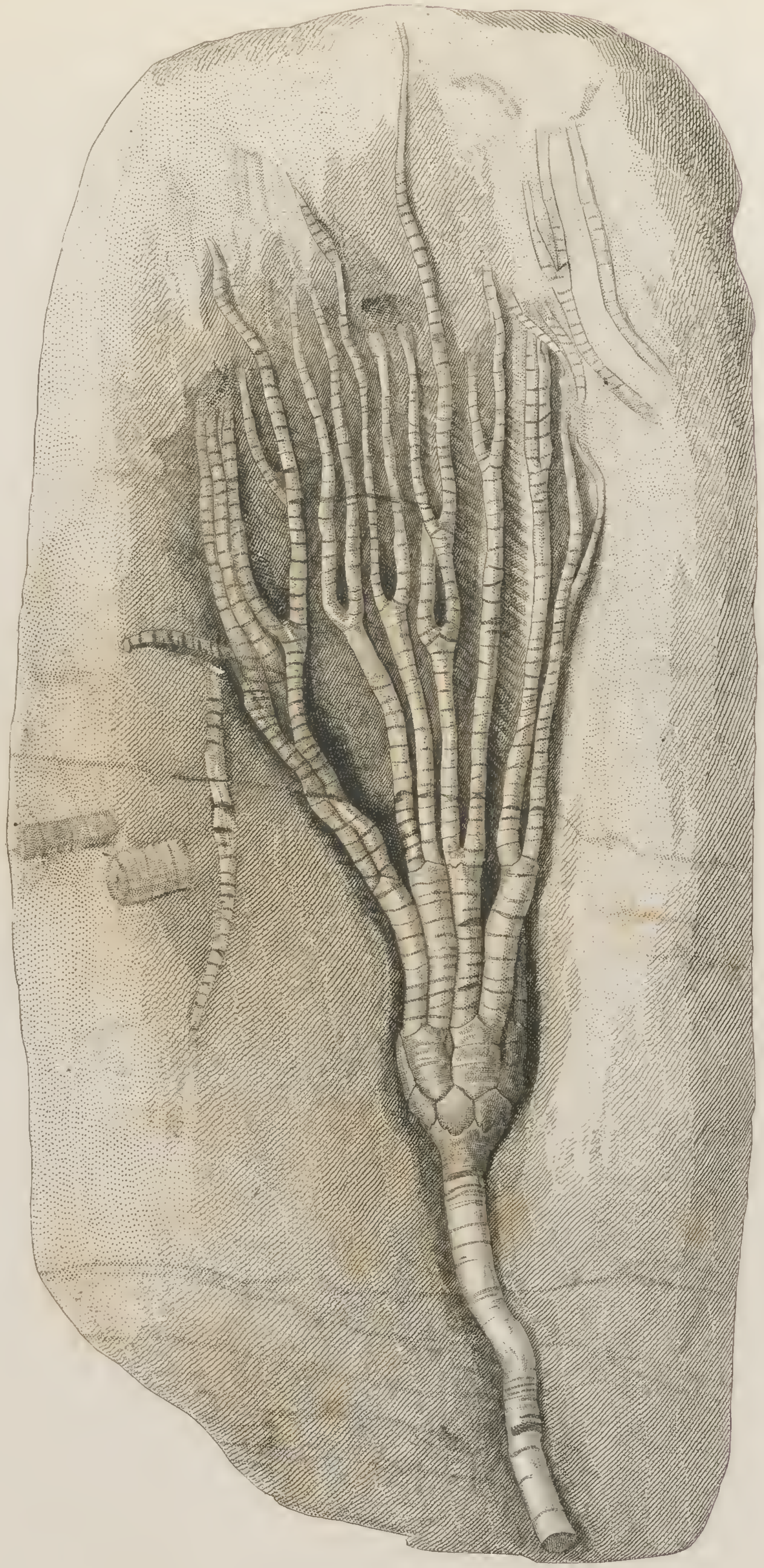

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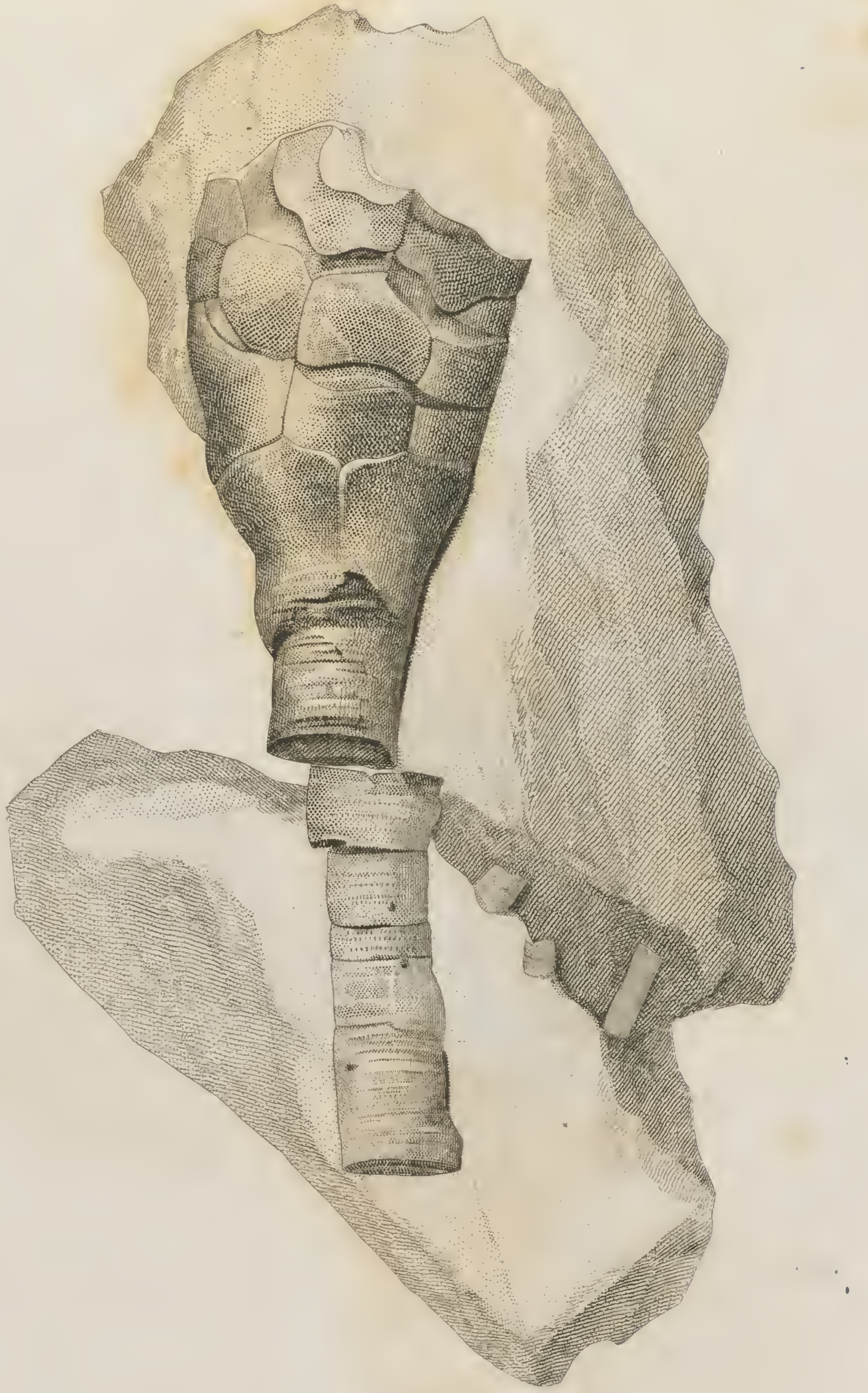

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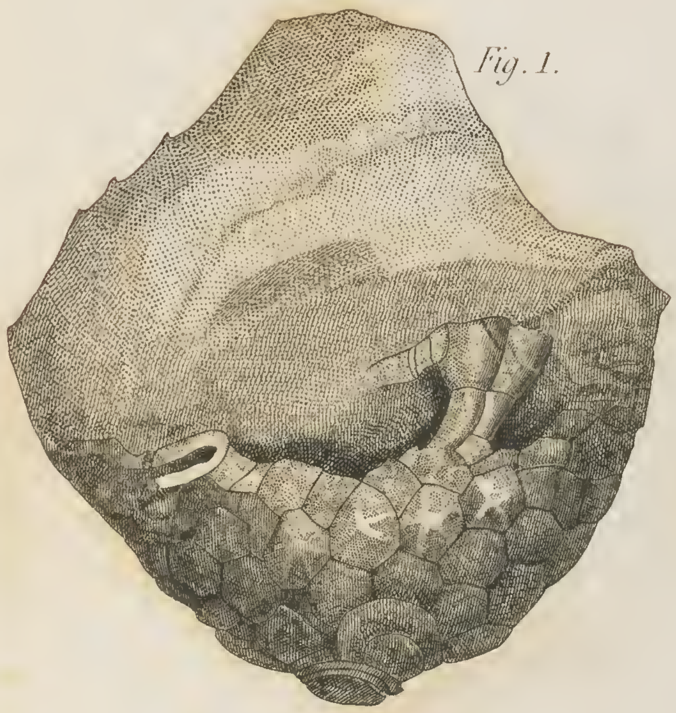

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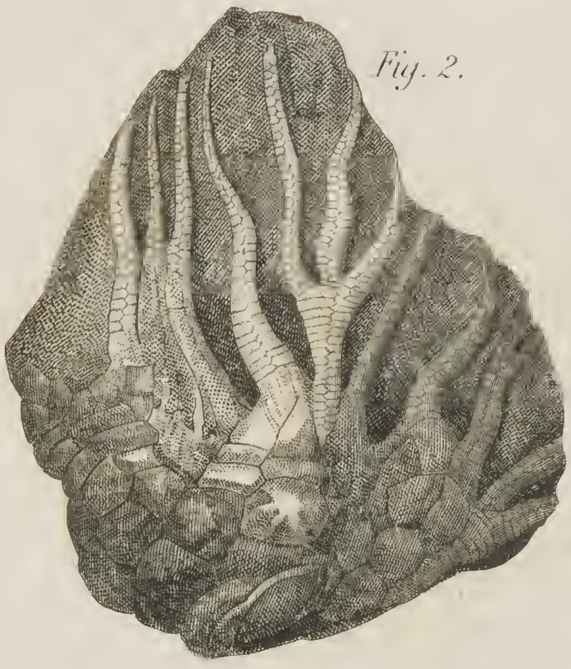

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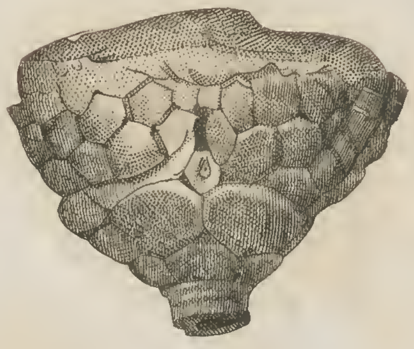

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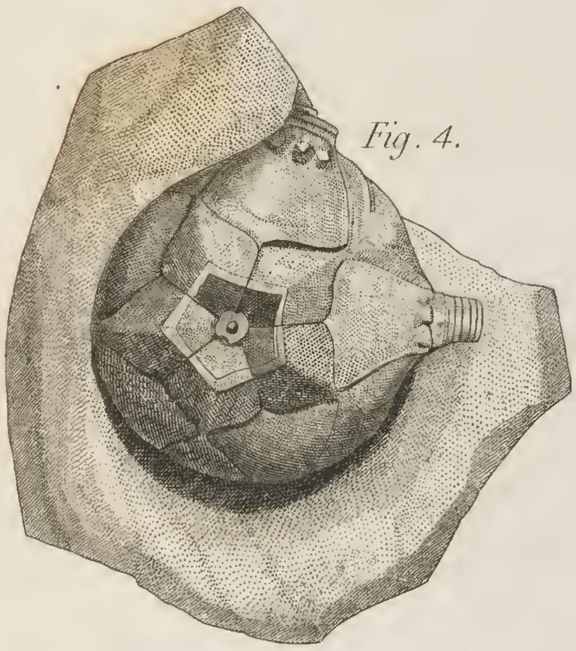

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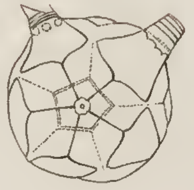

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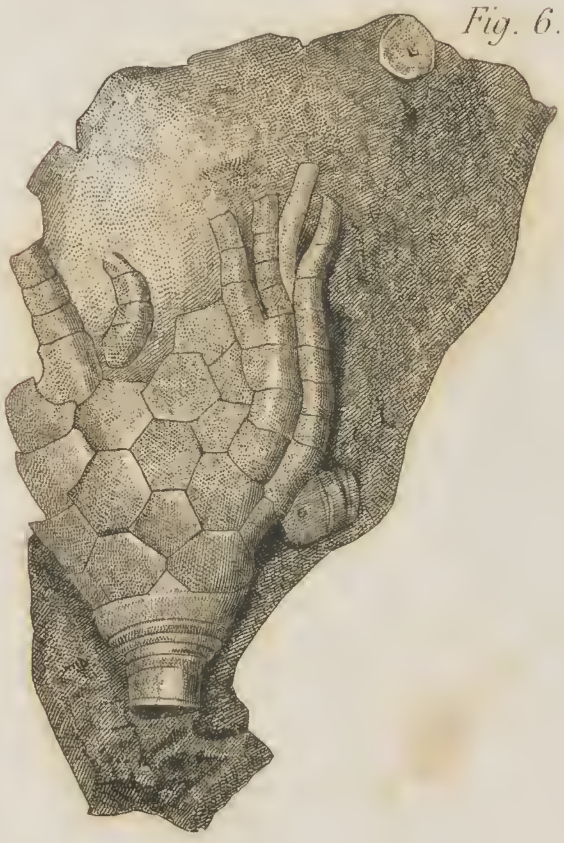

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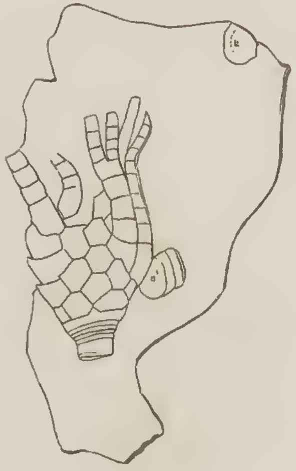

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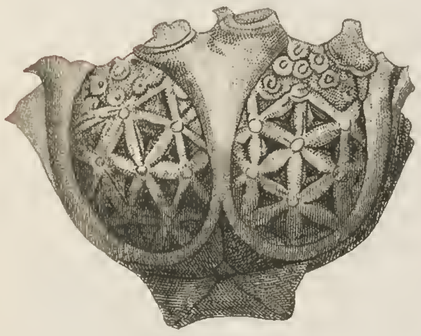

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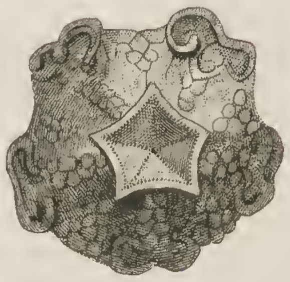

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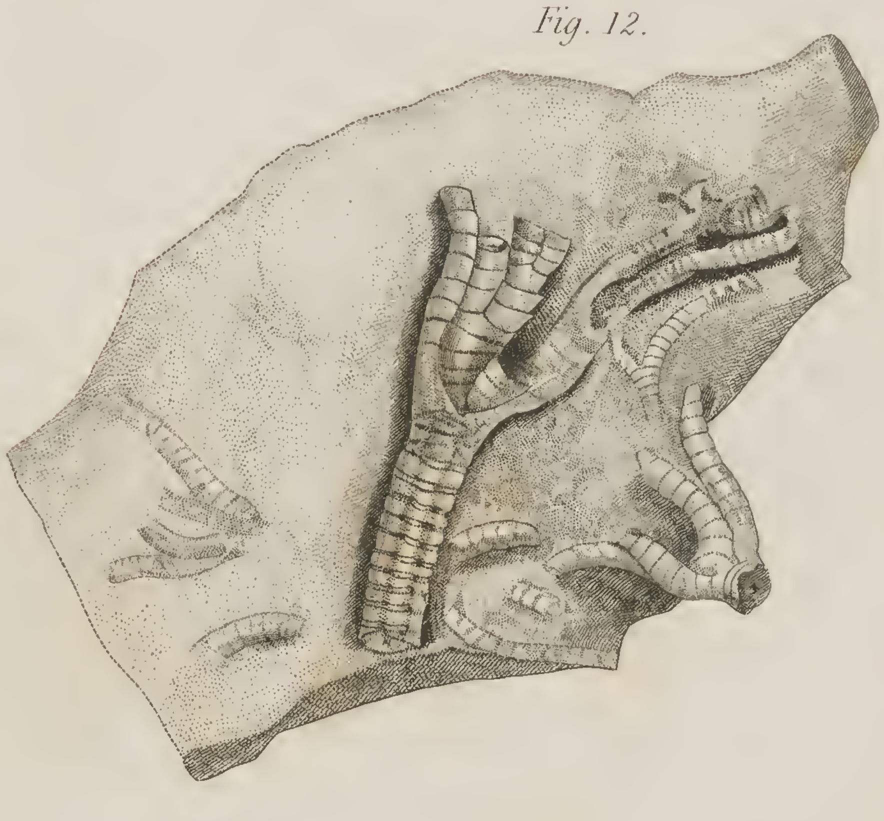

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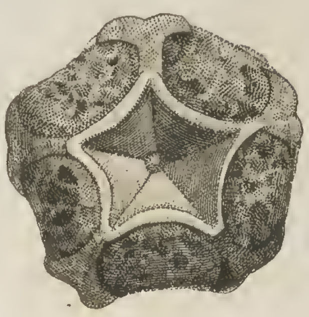

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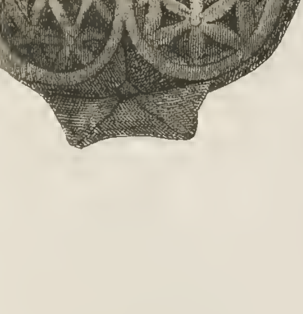

Fig. 11.

Encrini and Pentacrini found near Bristol.

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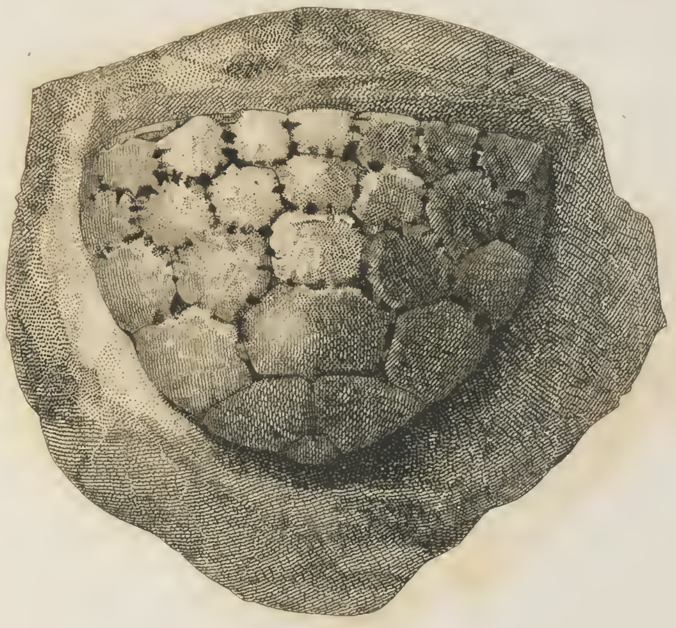

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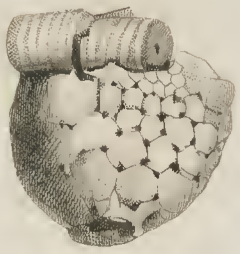

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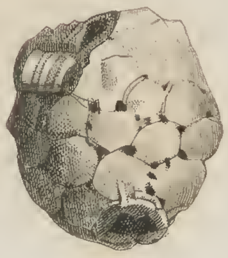

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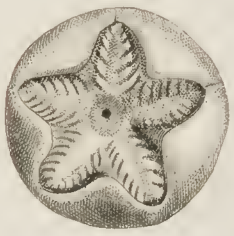

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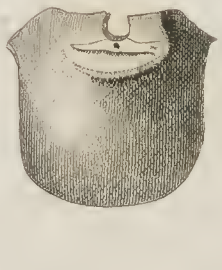

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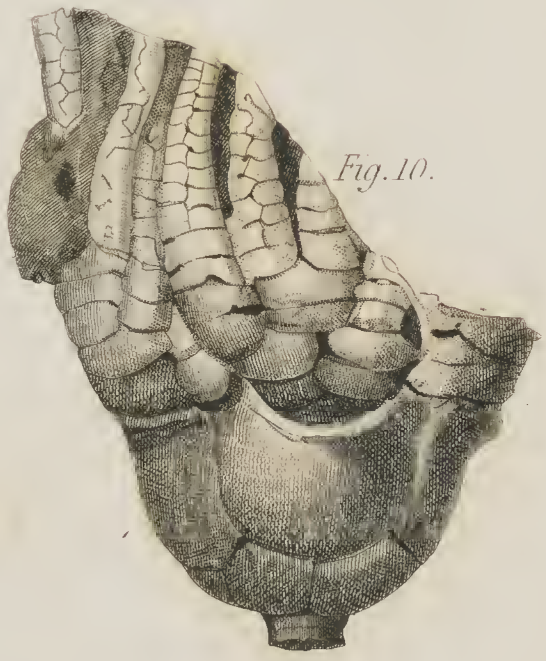

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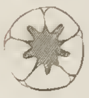

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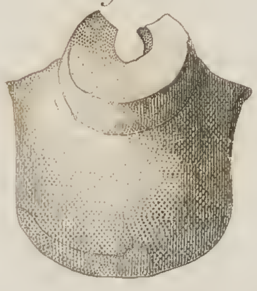

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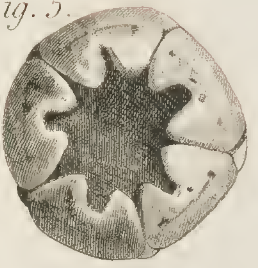

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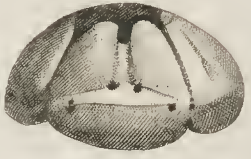

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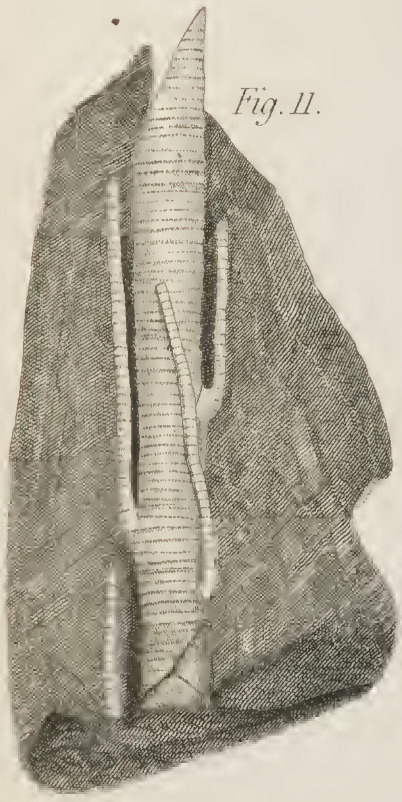


Fig. 12.

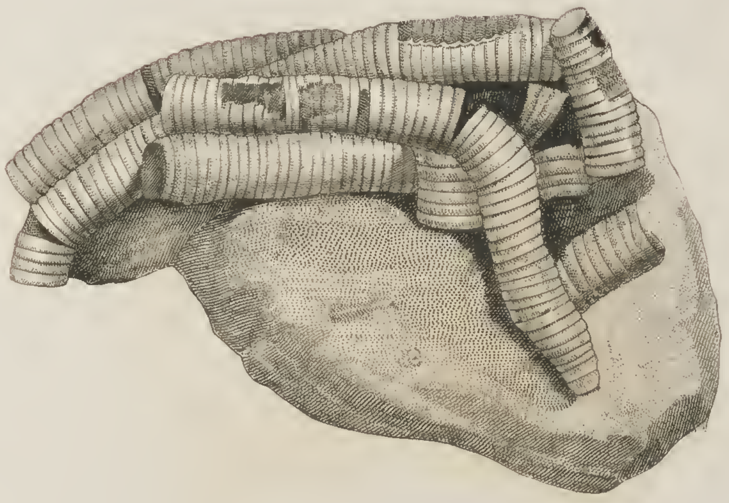
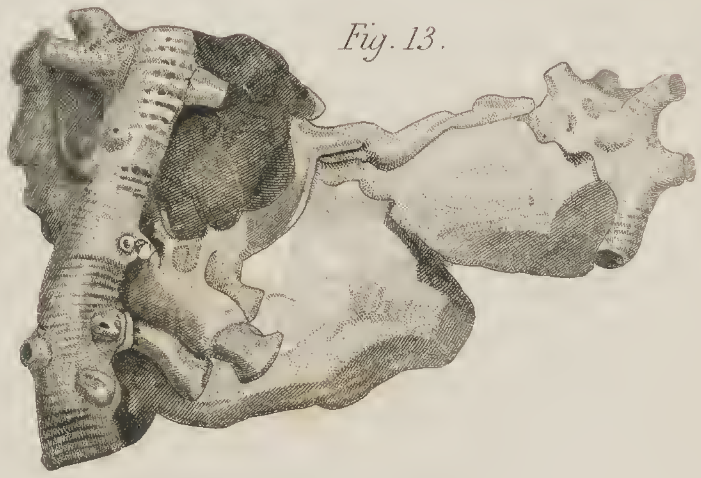


Fig. 13.



Encrini and Pentacrini found near Bristol.

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N^o. 1. View of the Range of Hills near the town of Kildare as seen from the Curragh.

N^o. 2. Circular View from the summit of Dunmurry Hill near the town of Kildare.

Continuation of Circular View from the summit of Dunmurry Hill.

Conclusion of View from Dunmurry Hill.

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London, Published by W. Phillips 1819.

G. Cooke sc.

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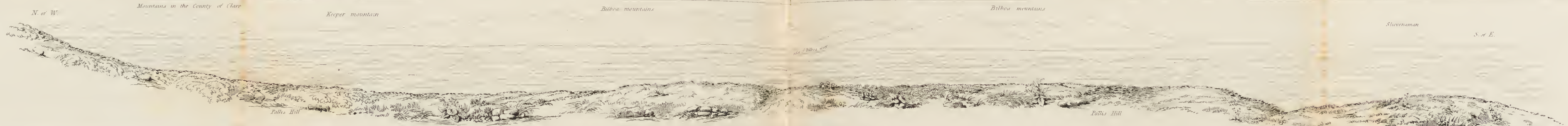
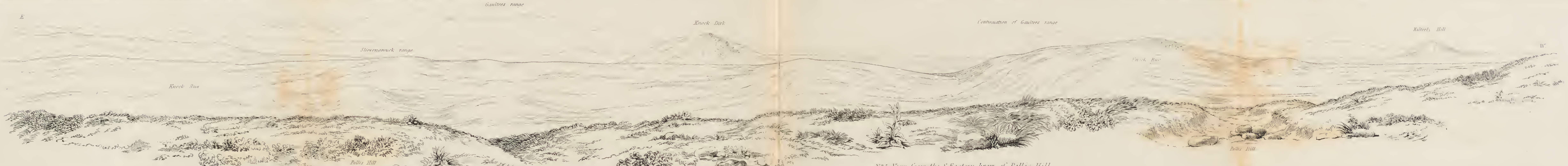
N° 3. View from the Western brew of the Killenaule Coal District.



N° 4. View from the Northern brew of Pallis Hill.



N° 5. View from the S. Eastern brew of Pallis Hill.

N° 6. View from the S. Eastern brew of the Gaultees mountains above Caher.

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Cooke sc.

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N.º 7. Circular View from the summit of Cronebane Hill

Continuation of Circular View from the summit of Cronebane.

N.º 8. View from the southern brow of the hill on the eastern side of the Scalp.

N.º 9. View from the Northern Peak of Little Sugarloaf

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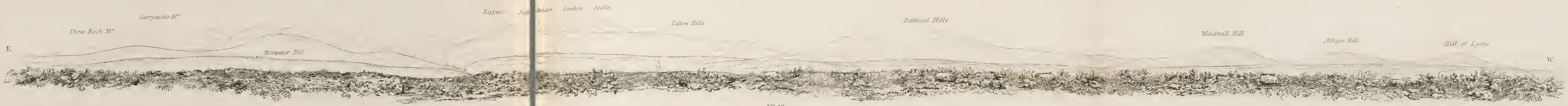
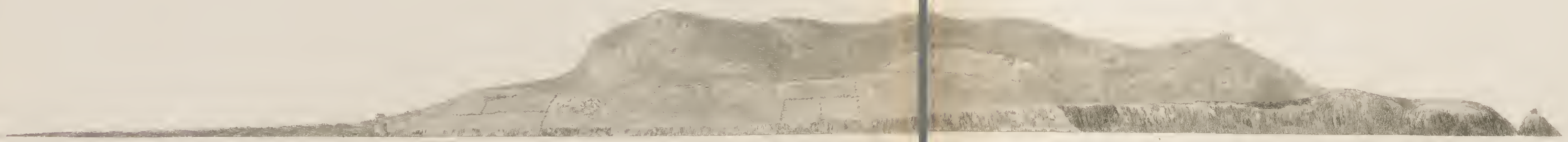


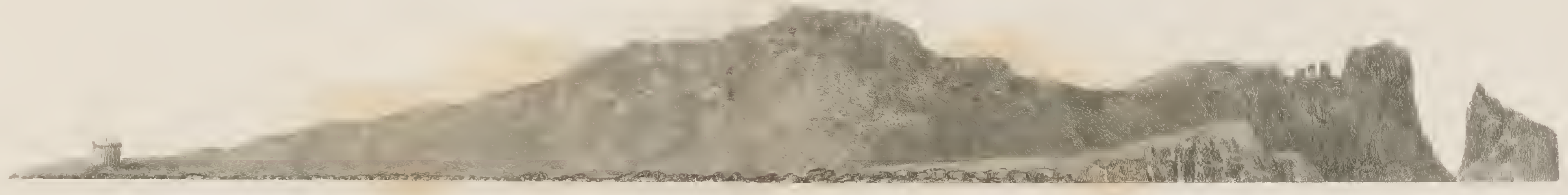
N° 10.
Nort bern aspect of the Mountains near Dublin, as seen from Ballykealy bridge, at the twelfth Lock on the Grand Canal.



N° 11.
Howtl from Dunleary.
E. of N.

N° 12.
Howth from Lambay.
W. of S.

N° 13.
Lambay from Howth.
E. of N.



N° 14.
Ireland's Eye from Howth.
N.

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Published by William Phillips, London 1819.

G. Cooke sc.

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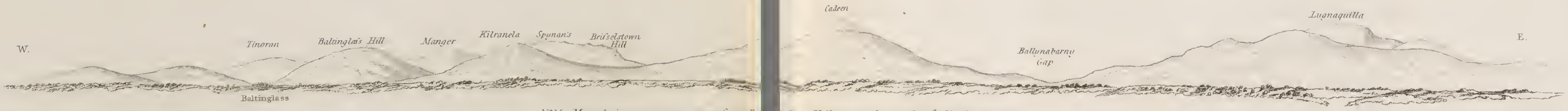
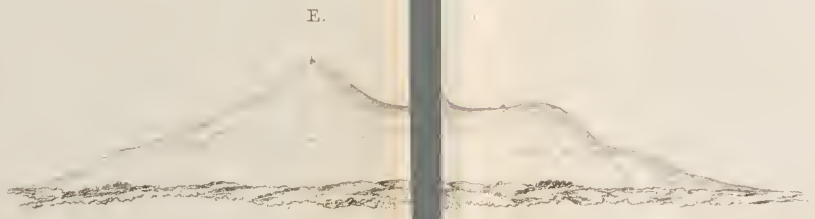
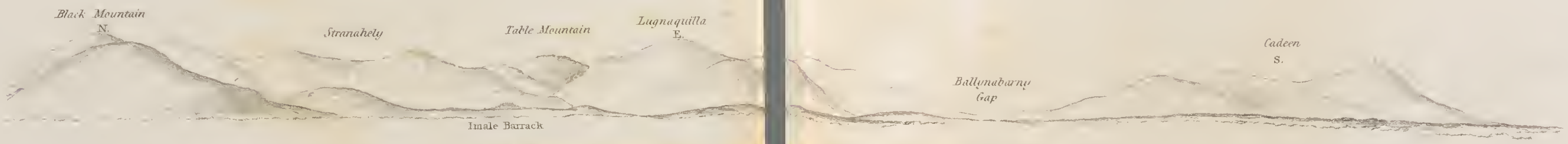


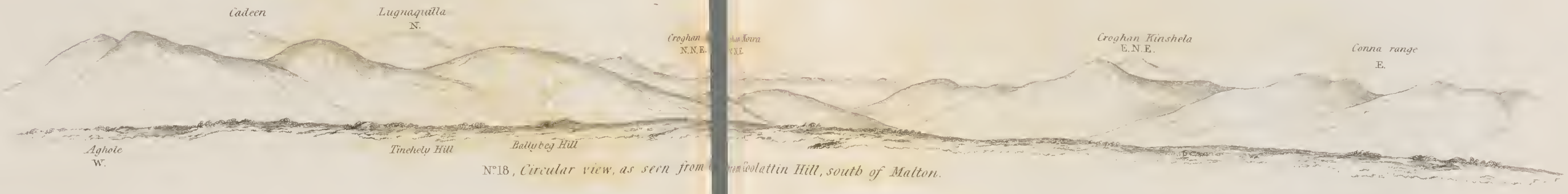
N°.15 *Mountain range as seen from Ea n Eagle Hill, one mile south of Hacketstown.*



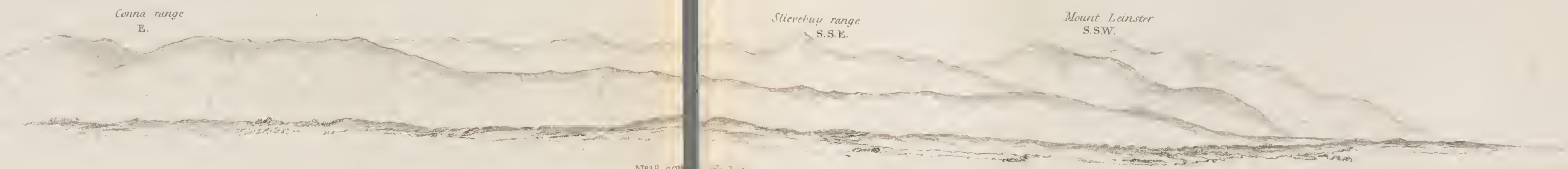
N°.16, *Cadeen from from Kilranela Hill.*



N°.17, *Mountains as seen from Bushfield ld near the centre of the Glen of Imale.*



N°.18, *Circular view, as seen from om Coolattin Hill, south of Malton.*



N°.18, con cluded.

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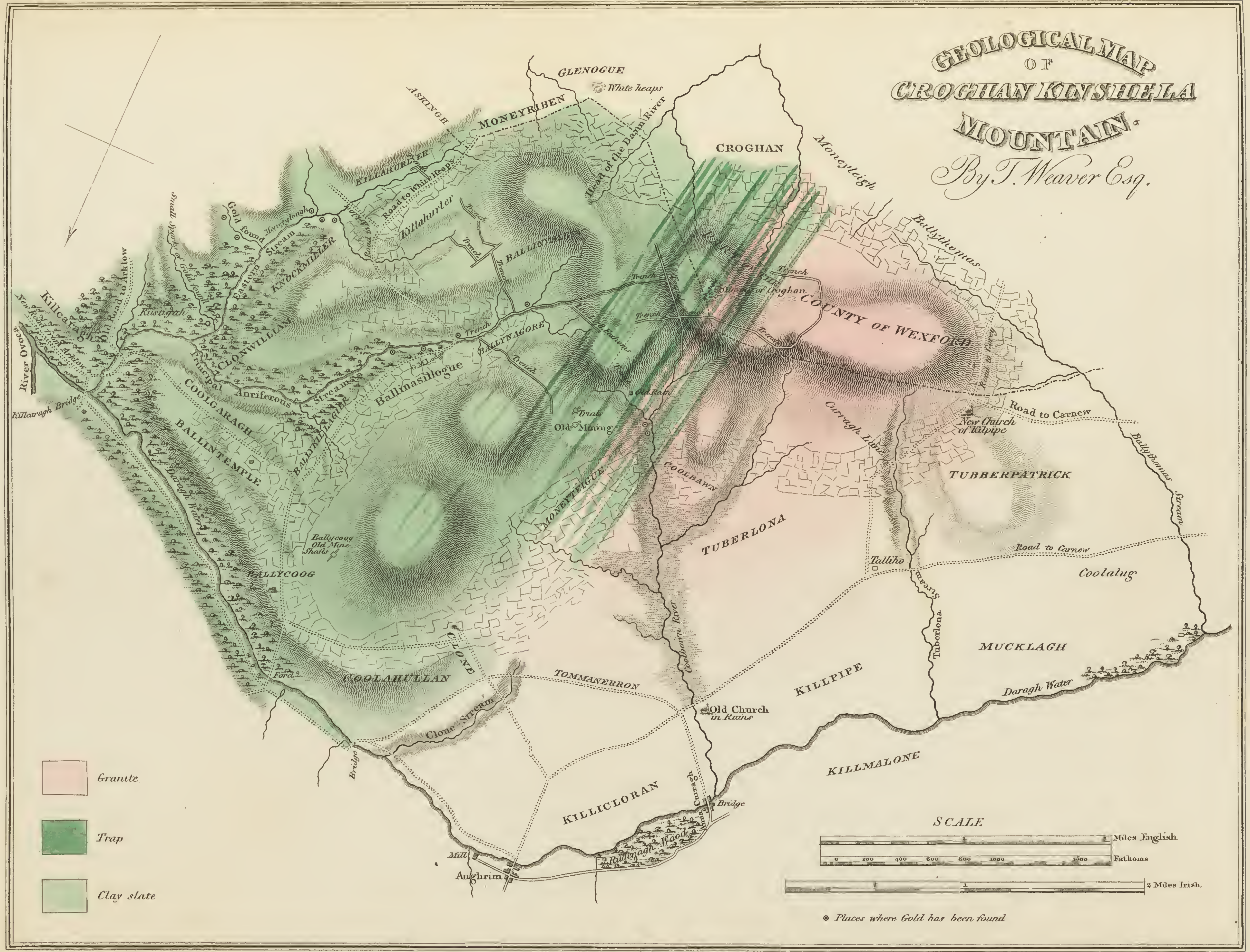

GEOLOGICAL MAP OF CROGHAN KINSHELA MOUNTAIN.

By T. Weaver Esq.

⊙ Places where Gold has been found

Cross. sculp. Glocester St. Queen Sq.

Published by W. Phillips, London 1819.

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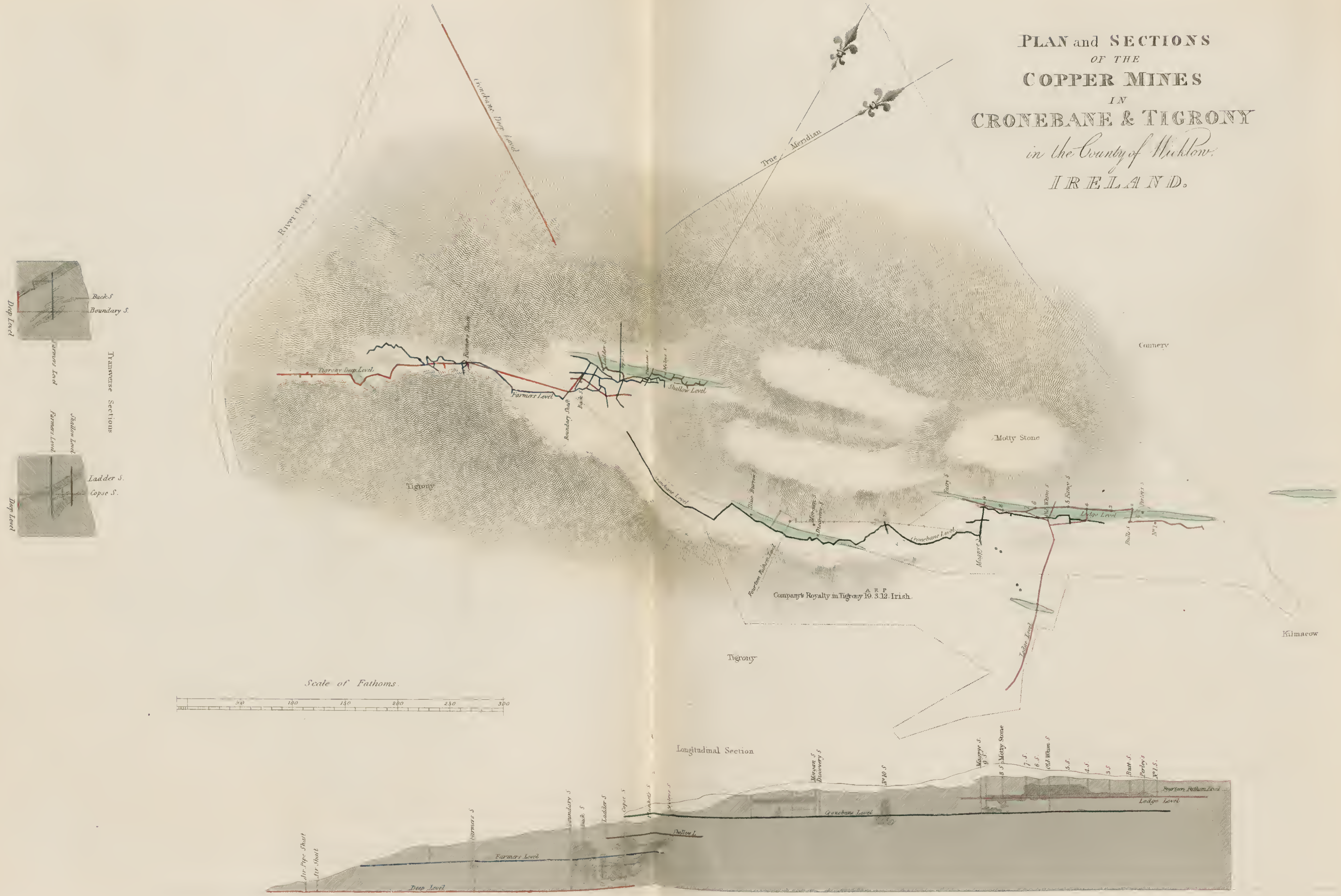
PLAN and SECTIONS
OF THE
COPPER MINES
IN
CRONEBANE & TIGRONY
in the County of Wicklow.
IRELAND.



Drawn by T. Weaver Esq.r

Published by W. Phillips, London, 1819.

Engraved by M.rs Lowry

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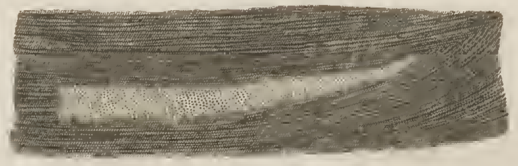
Fig. 1.



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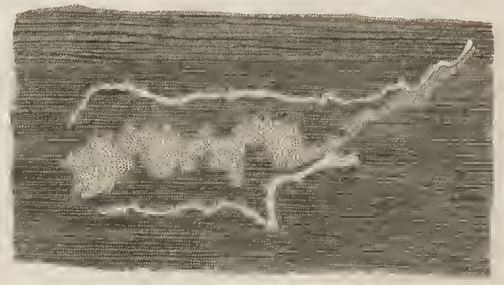

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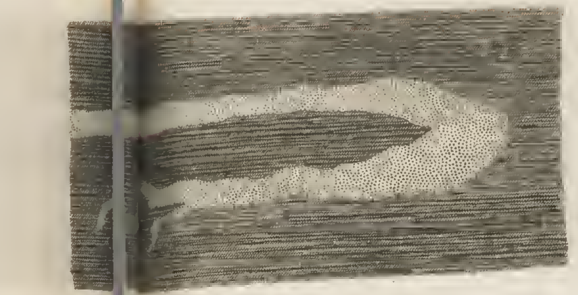

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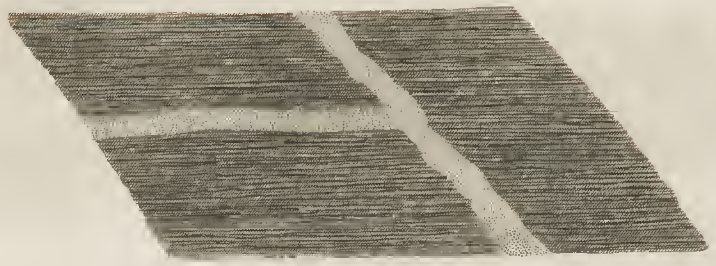


Fig. 5.

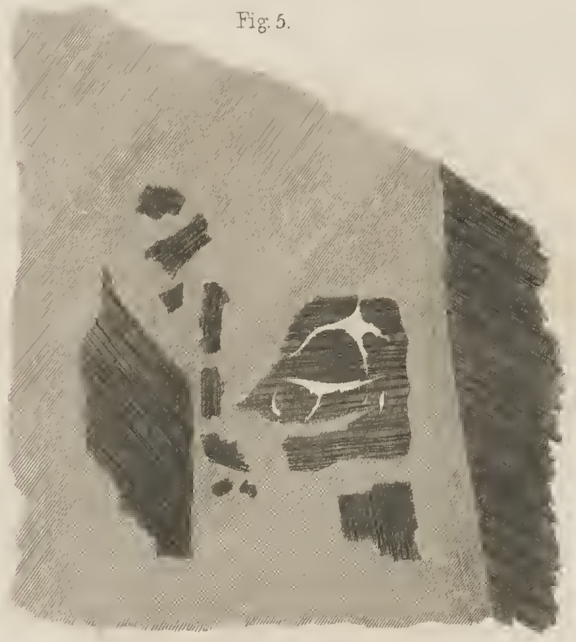
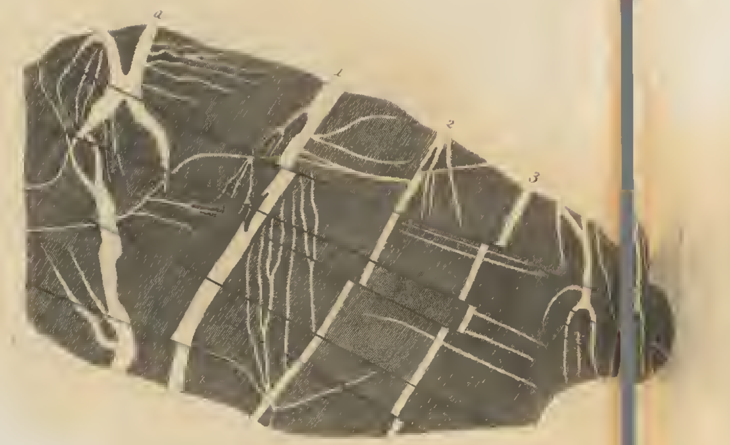


Fig. 6.



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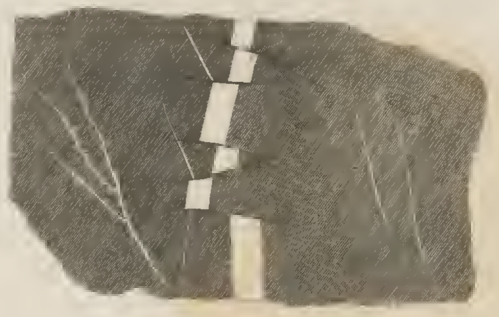
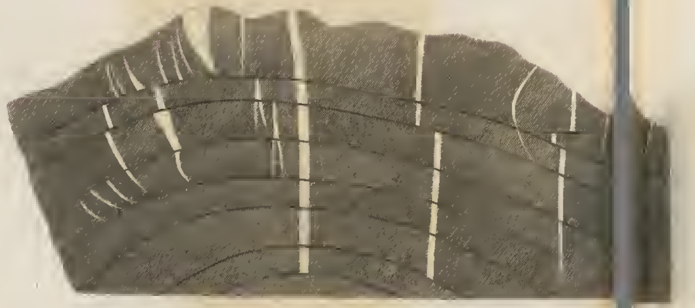


Fig. 8.



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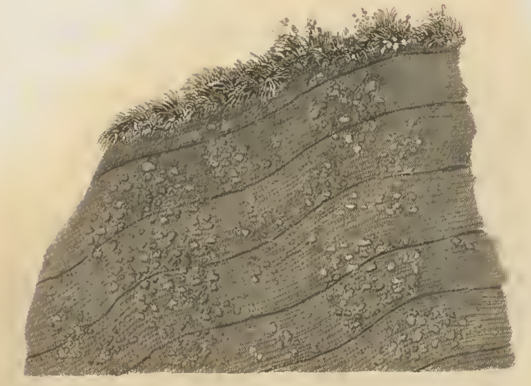

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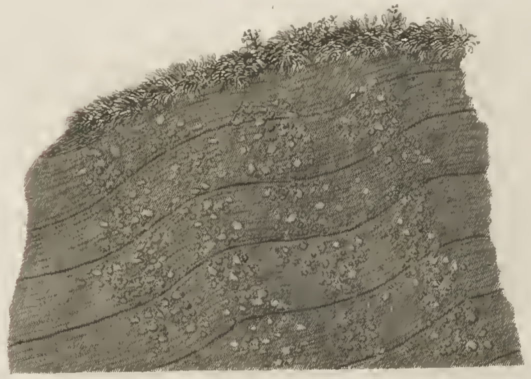

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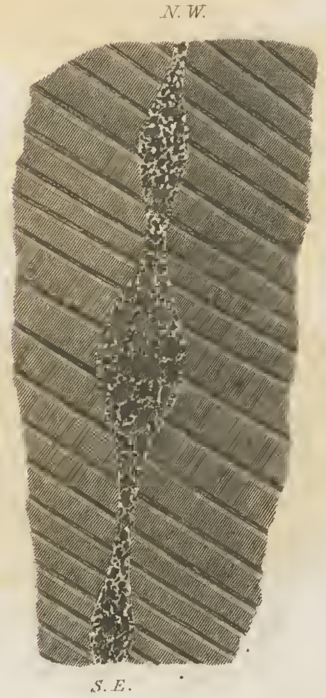

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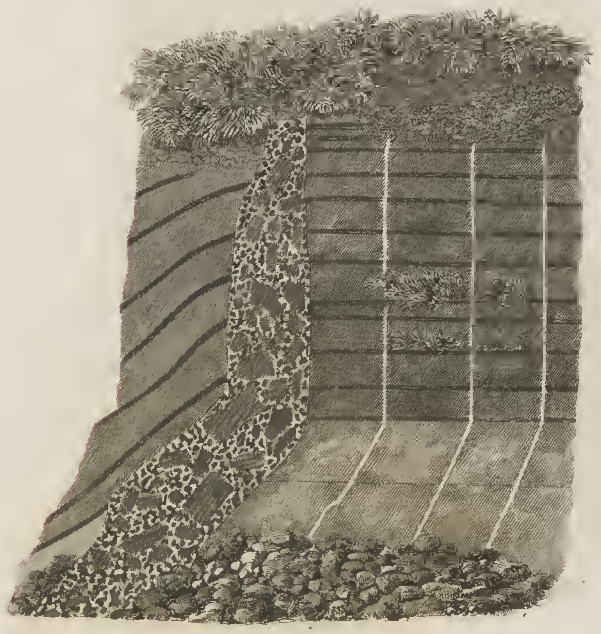

Drawn by T. Weaver
Published by William Phill s London, 1820
G. Cooke sc

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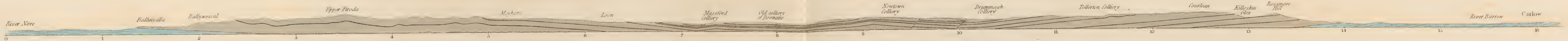
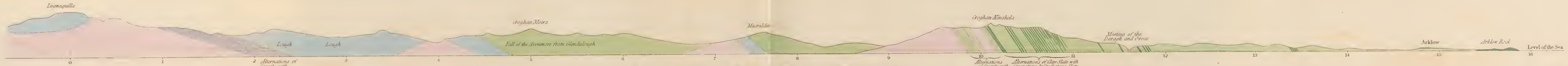


No 1 Section of the Castlecomer Coal District between the Nore on the West and the River Barrow at Carlow on the East.

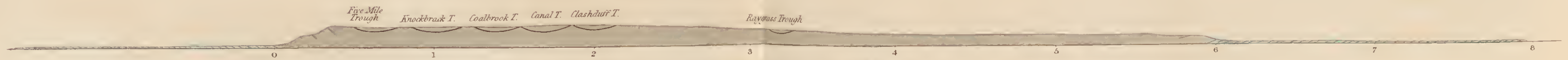
River Barrow
Carlow
Tinoran
Baltinglass Hill
Kilranela Hill
Cadeen
Lugnaquilla
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Alternations of Mica Slate with Granite
Alternations of Rock and Greenstone in M. Slate
Bed of Hornblende Granite
Alternations of Mica Slate with Granite

No 2 Section from the River Barrow at Carlow on the West to Lugnaquilla Mountain on the East.


Lugnaquilla
Lough
Lough
Croghan Moira
Fall of the Avonmore from Glendalough
Macreddin
Croghan Kinshela
Meeting of the Daragh and Ovoca
Arklow
Arklow Rock
Level of the Sea
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Alternations of Granite with Mica Slate
Alternations of Granite with Clay-Slate
Alternations of Clay-Slate with Greenstone & Greenstone Slate

No 3 Section from Lugnaquilla Mountain on the West, to the Sea at Arklow on the East.

- Granite
- Mica-slate
- Clay-slate
- Trap
- Fletz limestone
- Coal formation



No 4 Section of the Killenaule Coal District between Littlefield on the N.W. and Lismullin on the S.E.

Scale of Irish Miles.
¼ ½ 1 2 miles

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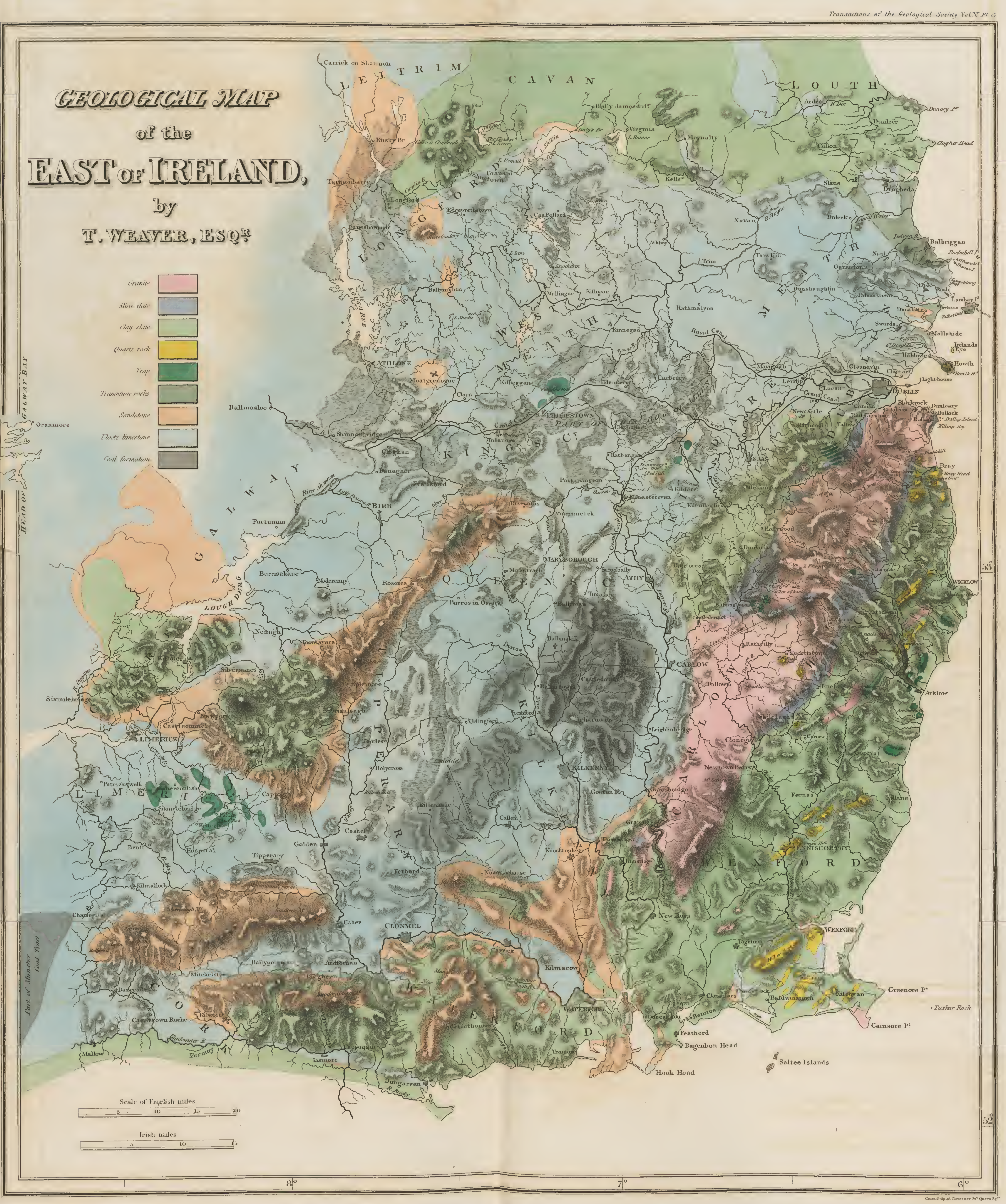
GEOLOGICAL MAP
# of the
EAST OF IRELAND,
by
T. WEAVER, ESQ.R



Cross. ſculp. 46. Gloucester St.t Queen Sq.re

Published by W.m Phillips London. 1819.

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Primitive Crystal of the SULPHATE of BARYTES, and its Modifications.

Fig. 1.
Primitive

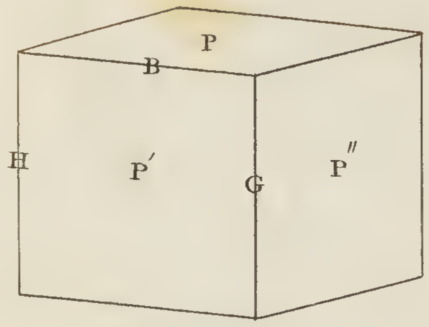


Fig. 2.

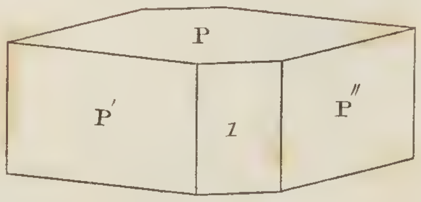


Fig. 3.

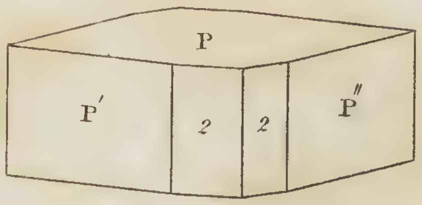
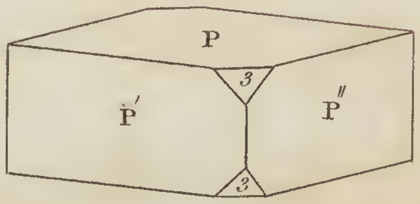


Fig. 4.



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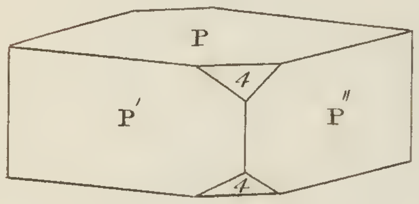

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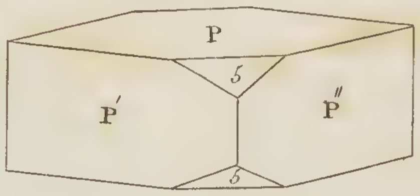

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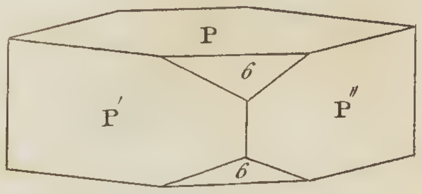
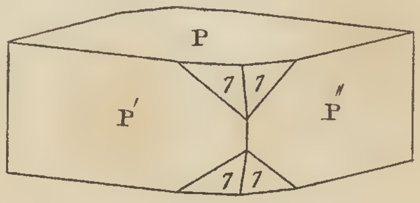


Fig. 8.



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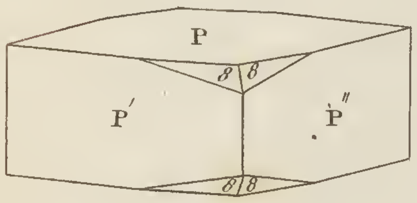
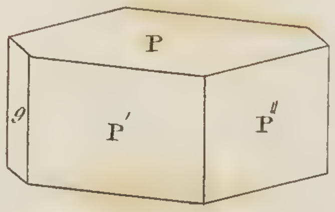


Fig. 10.



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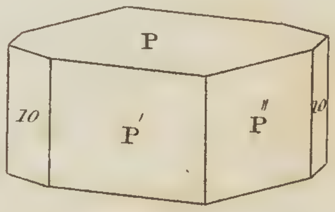

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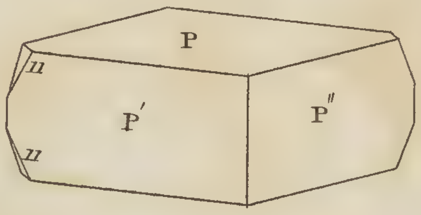

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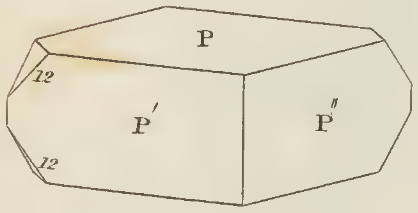

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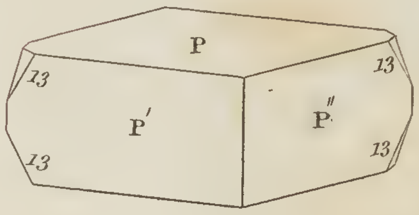


Fig. 15.

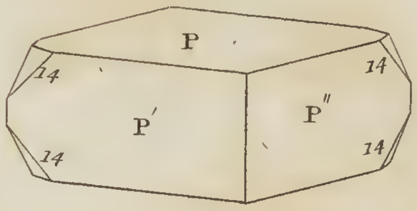


Fig. 16.

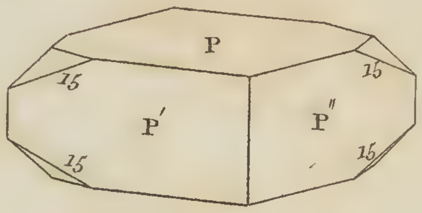


Fig. 17.

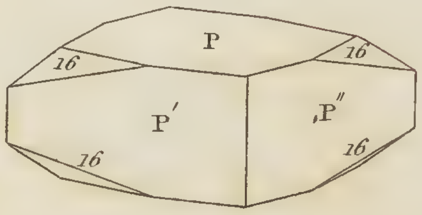


Fig. 18.

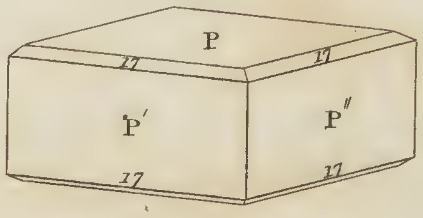


Fig. 19.

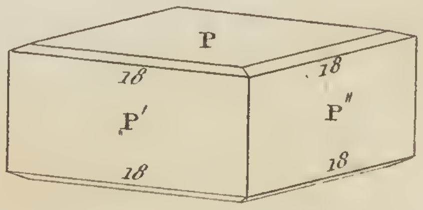
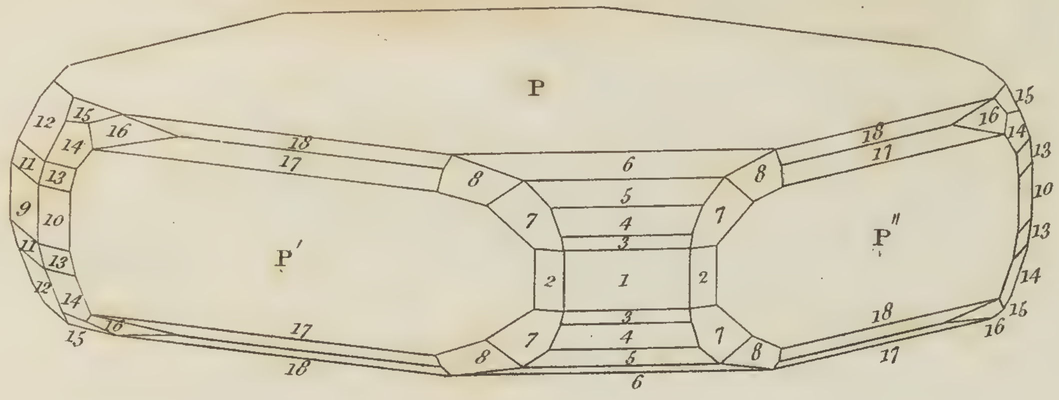


Figure exhibiting the planes of all the Modifications in combination with those of the Primitive Crystal.

Fig. 20.



W. Phillips delin.

Engraved by Miss Lowry.

Published by W. Phillips, London, 1819.

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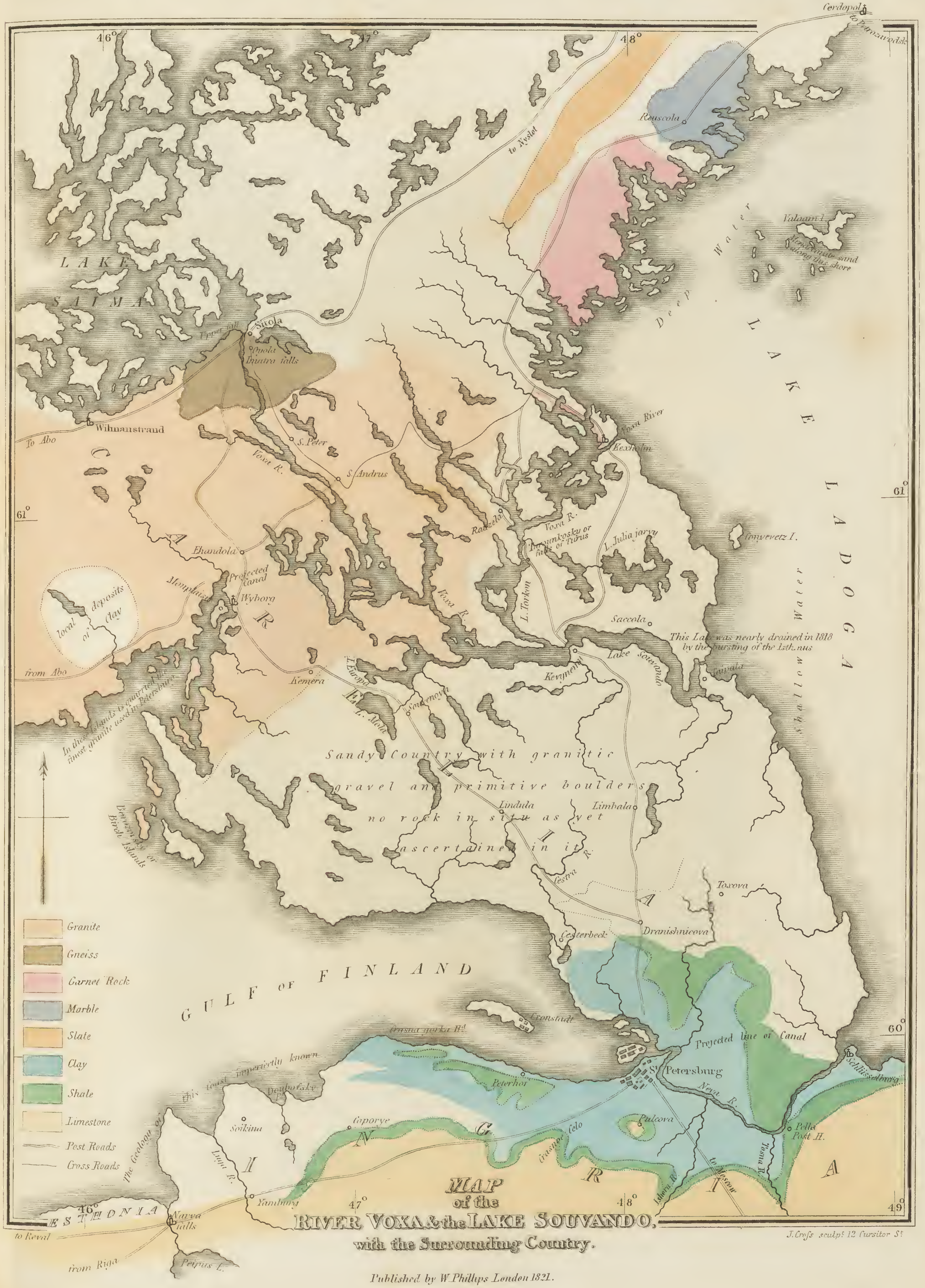

MAP of the RIVER VOXA & the LAKE SOUVANDO, with the Surrounding Country.

J. Cross sculpt 12 Cursitor St.

Published by W. Phillips London 1821.

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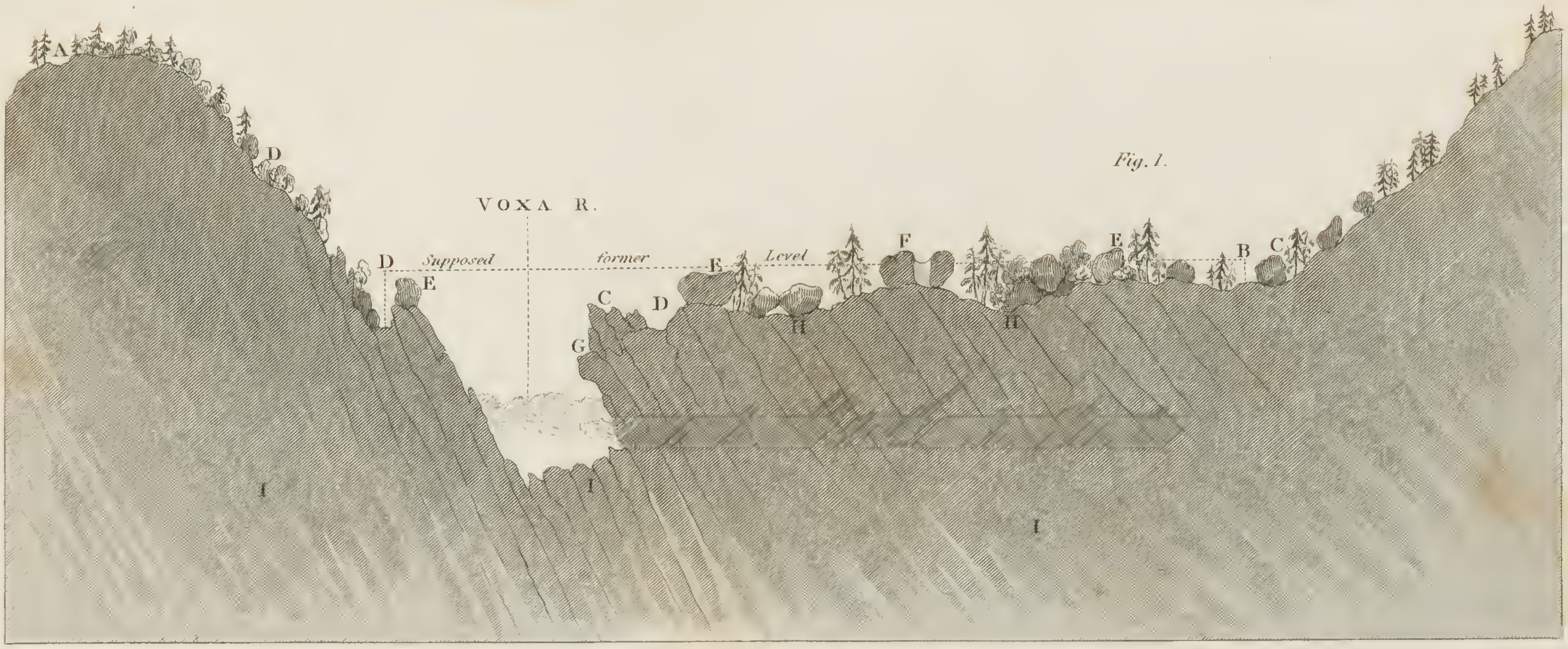
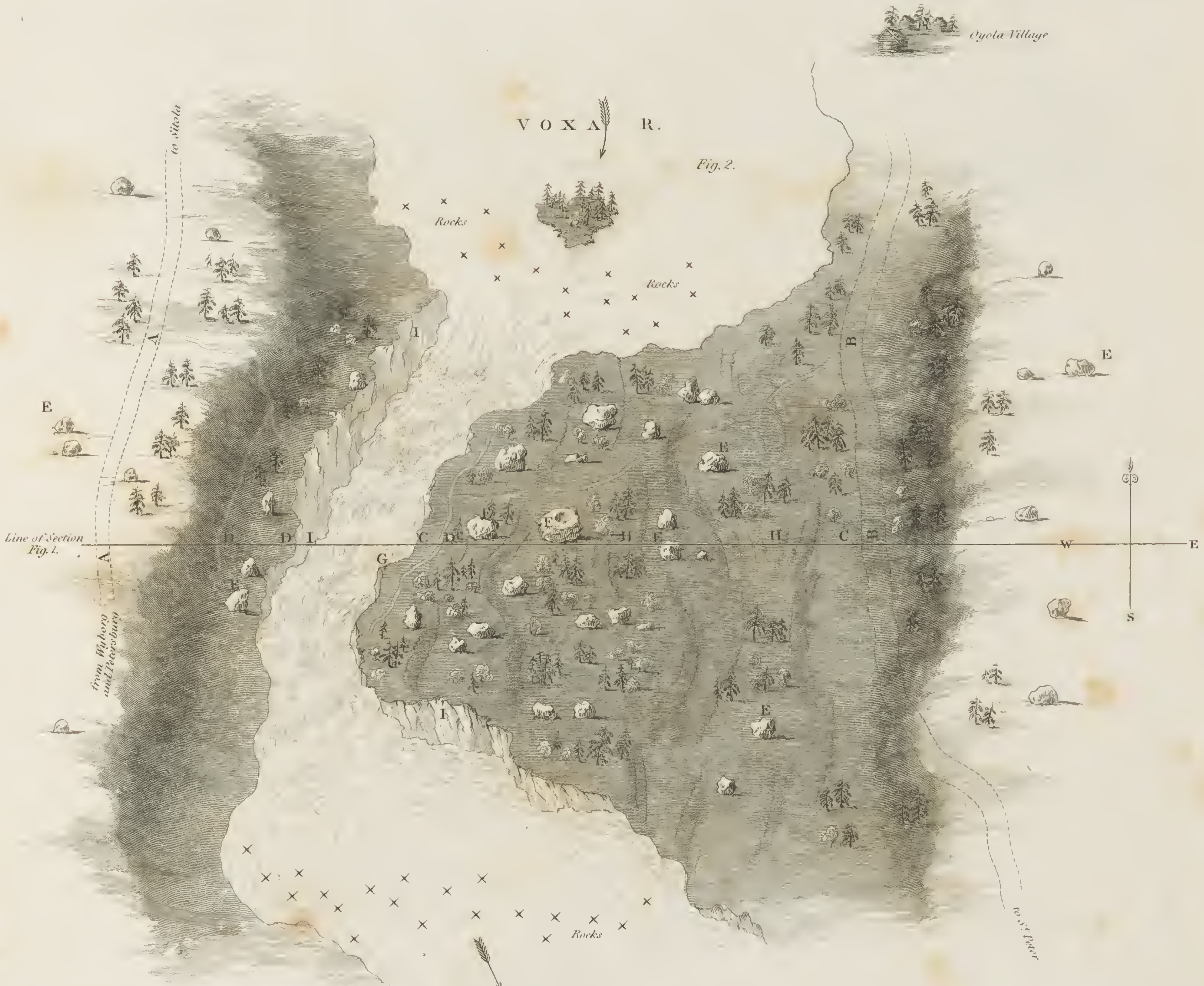


Plan and Section of the Falls of Imatra formed by the river Voxa.



Drawn by the Hon. W. T. H. Fox Strangways.

A. *Post Road from Wyborg to Sitola.*
B. *Road from Sitola to St. Peter.*
C.C. *Elevated Rocky Plain.*
D. *Paths and Gravel Walks in the Shrubberies.*
E. *Boulders.*

Published by W. Phillips, London, 182[illegible].

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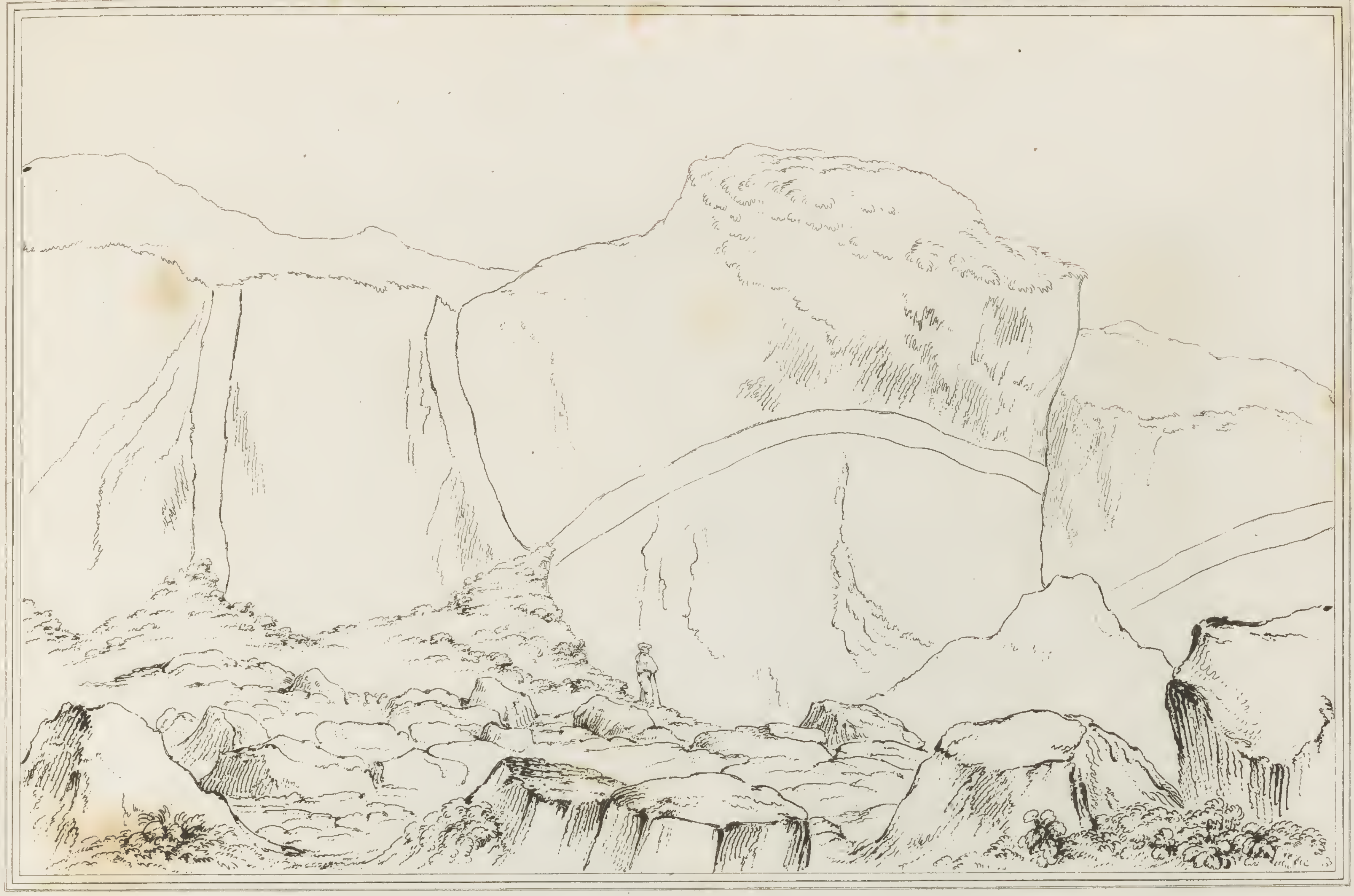
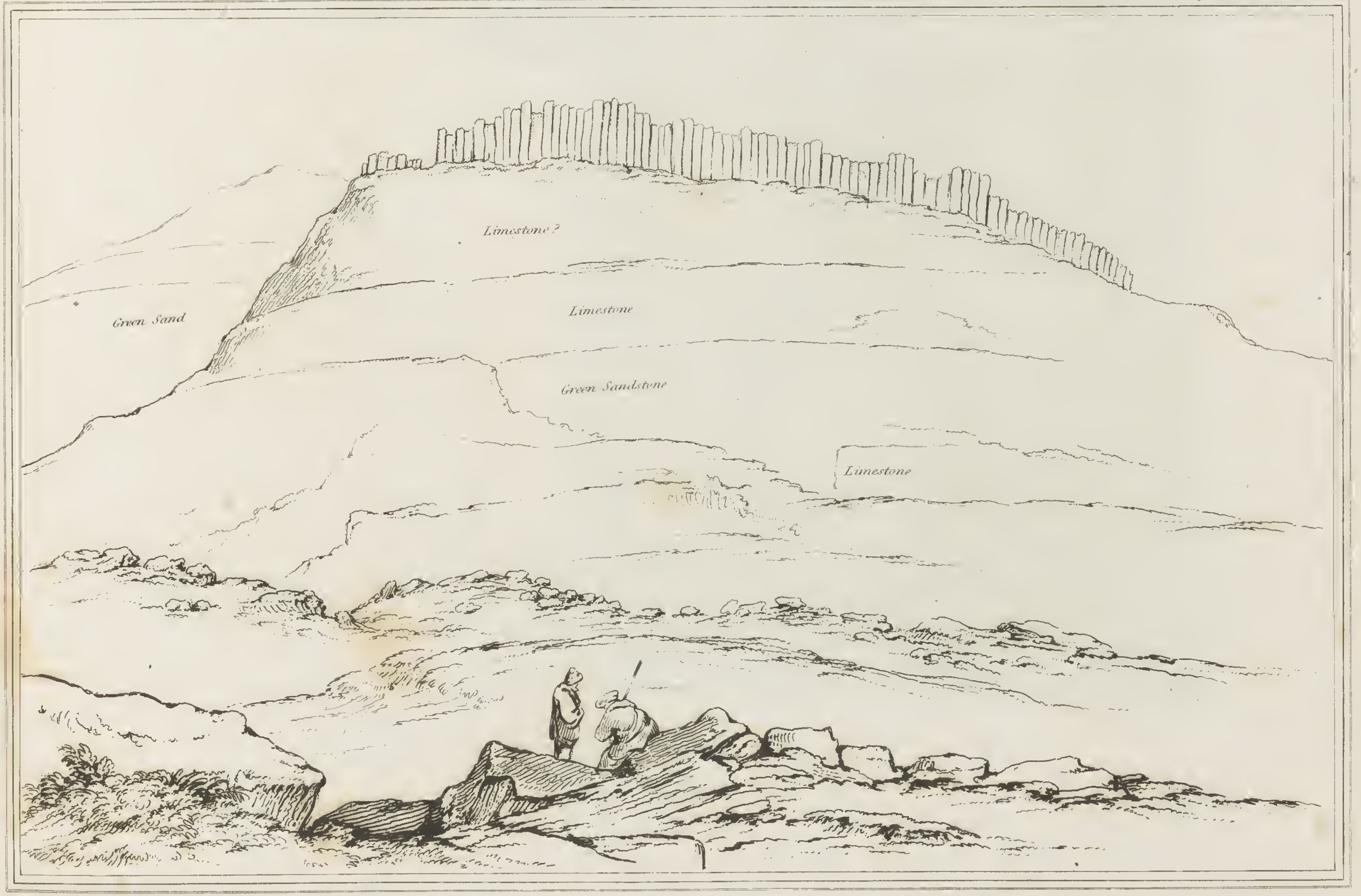
Fig. 1.



Basaltic dykes in the Isle of Mull.

Fig. 2.



Drawn by the Rt. Hon. Earl Compton, Pr. G.S.

Stona Buoch; or promontory of the Goats: Isle of Mull.

Published by W. Phillips, London, 1821.

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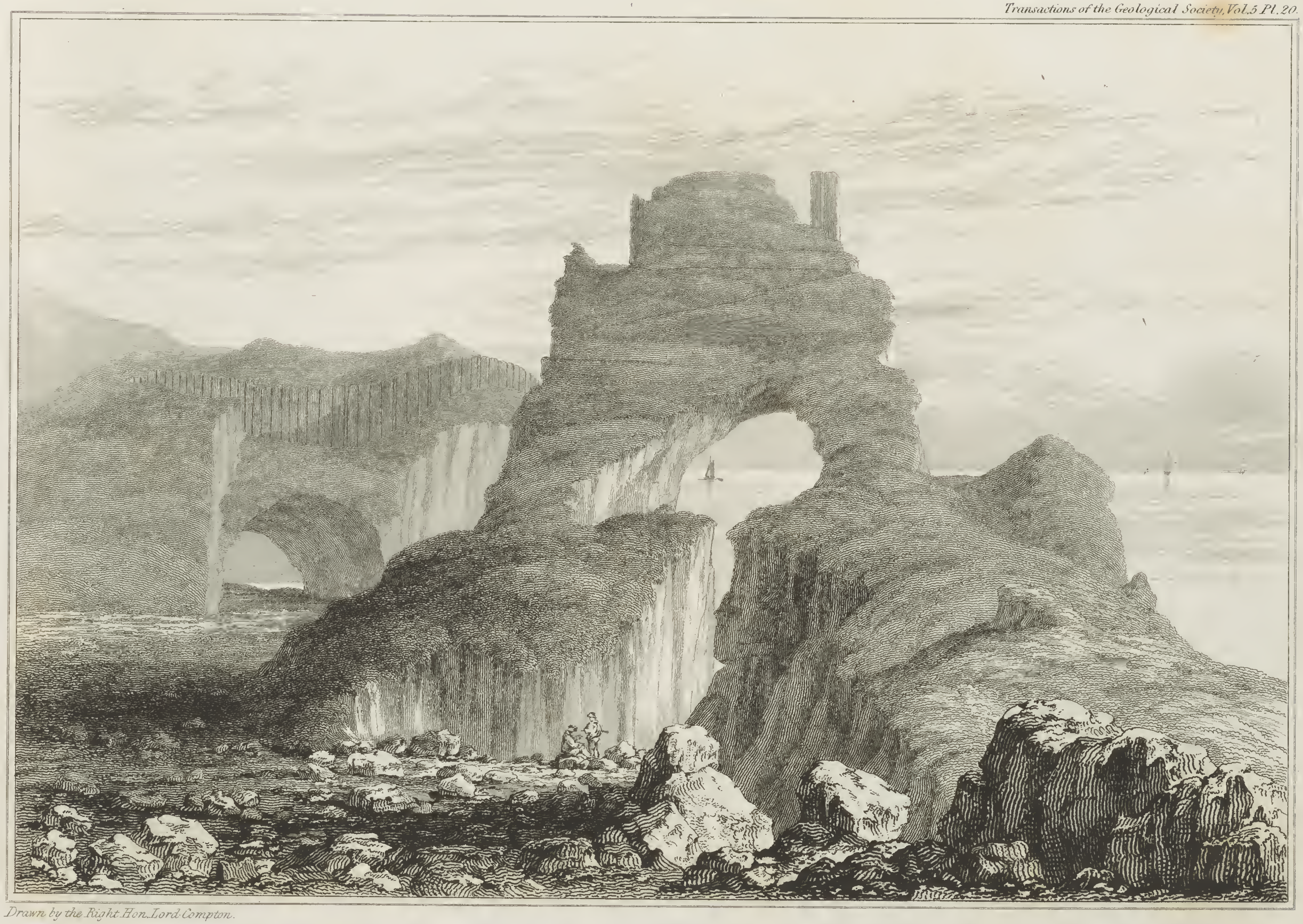

Drawn by the Right Hon. Lord Compton.

Arched rocks in the Isle of Mull

Published by W. Phillips, London. 1821.

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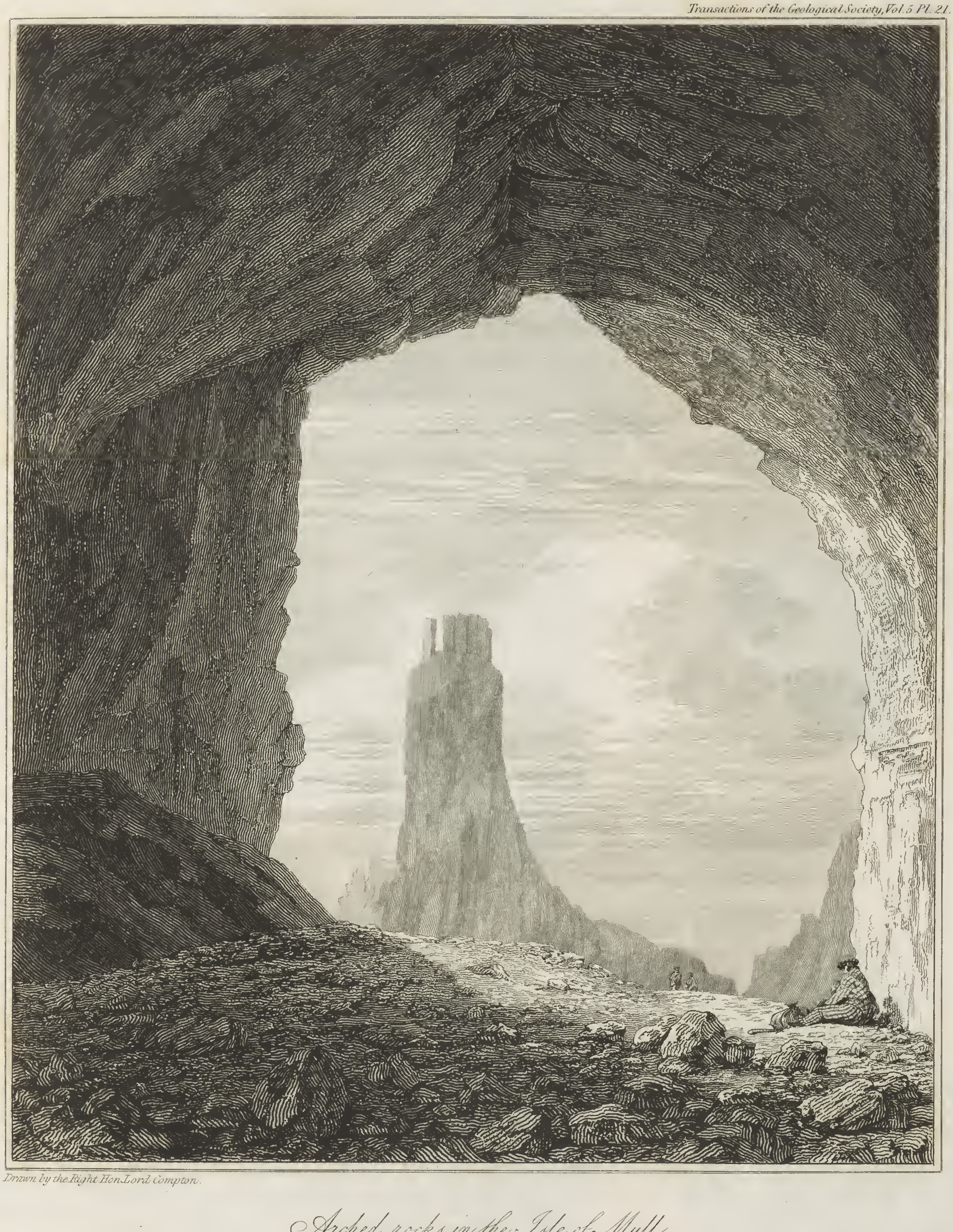

Drawn by the Right Hon. Lord Compton.

Arched rocks in the Isle of Mull.

Published by W. Phillips, London, 1821.

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Fig. 1.

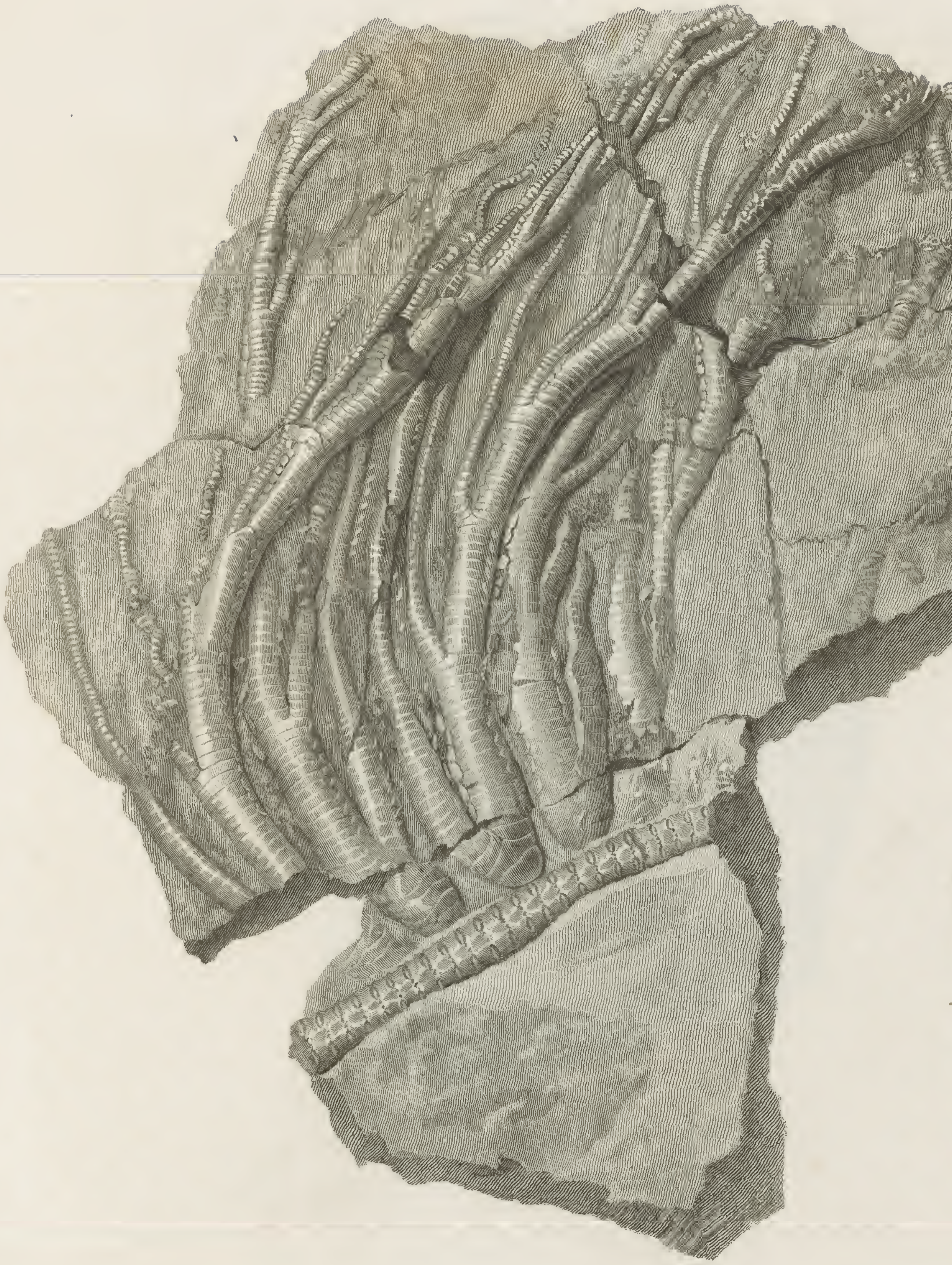
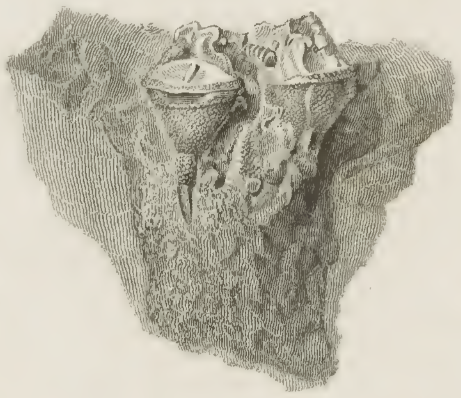


Fig. 2.



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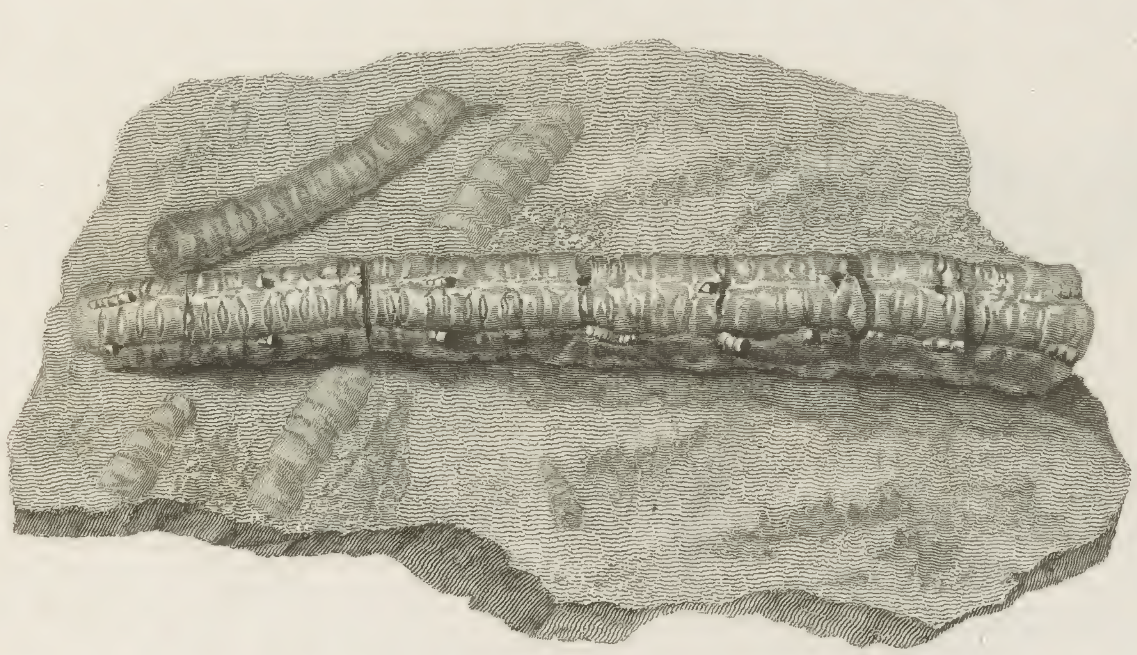
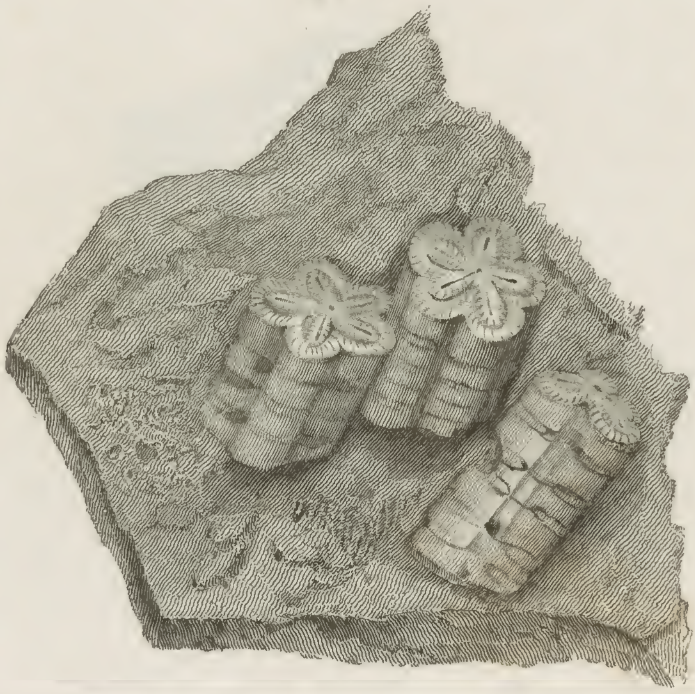


Fig. 4.



Drawn by George Cumberland.

Engraved by George Cooke.

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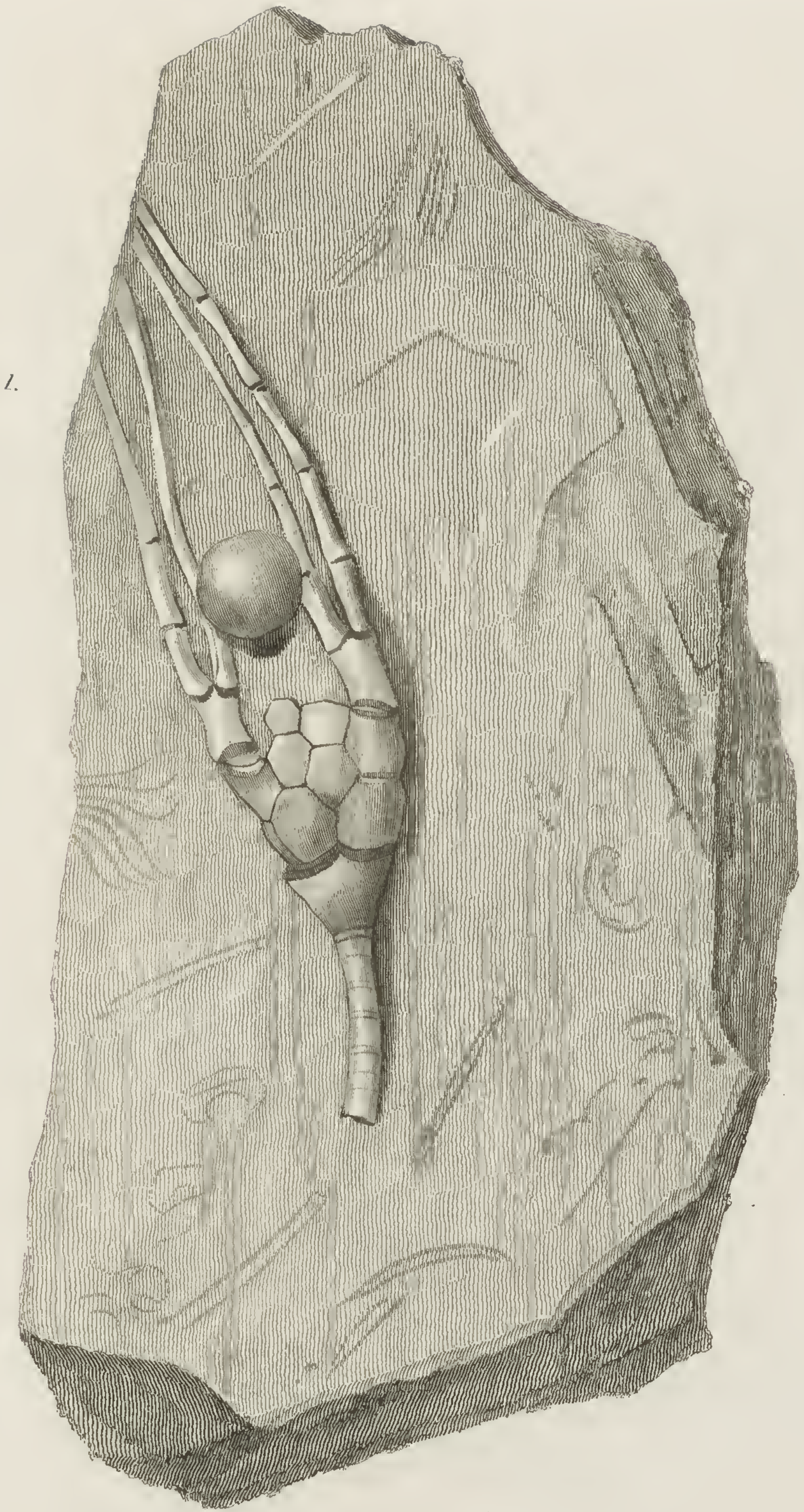
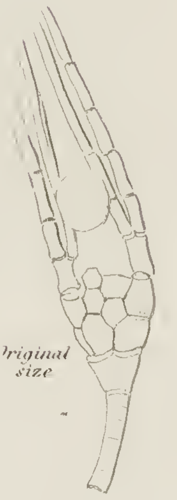
Fig. 1.





Original size

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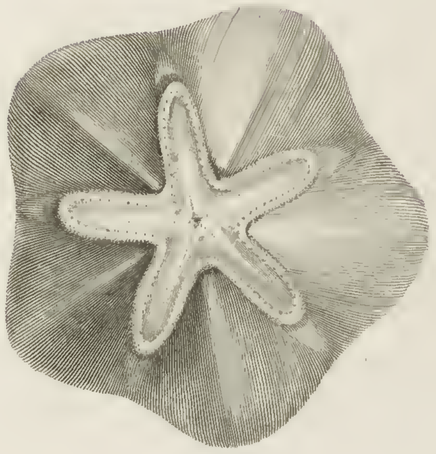


Fig. 3.

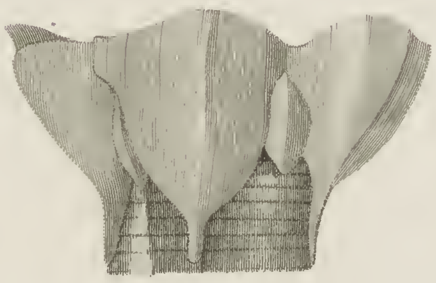
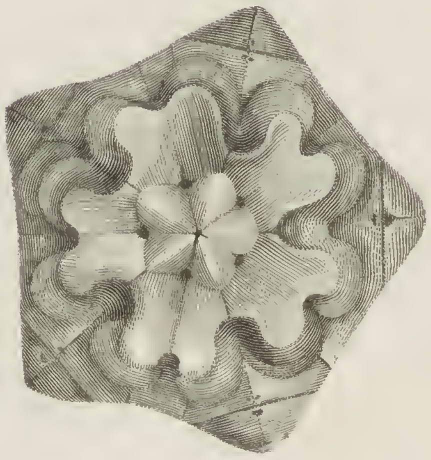


Fig. 4.



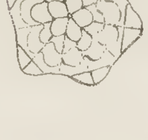


Fig. 5.

Drawn by George Cumberland.

Engraved by George Cooke.

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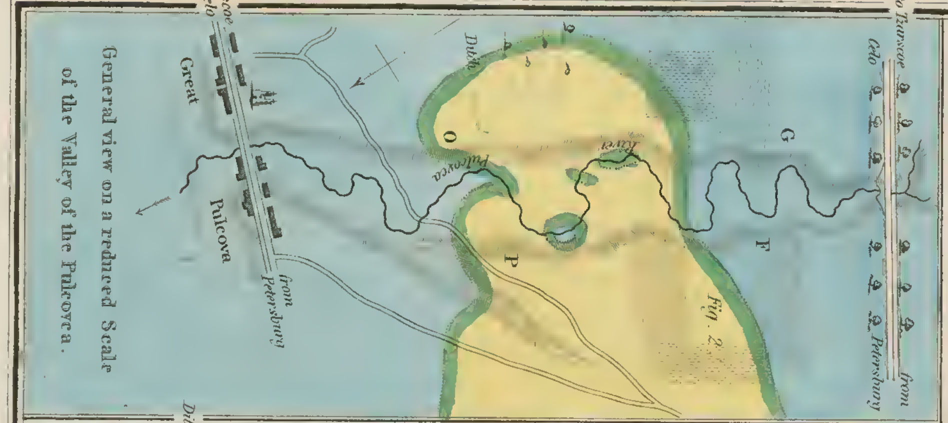


General view on a reduced Scale of the Valley of the Pulcovca.

MAP of PART of the COURSE of the PULCOVCA.

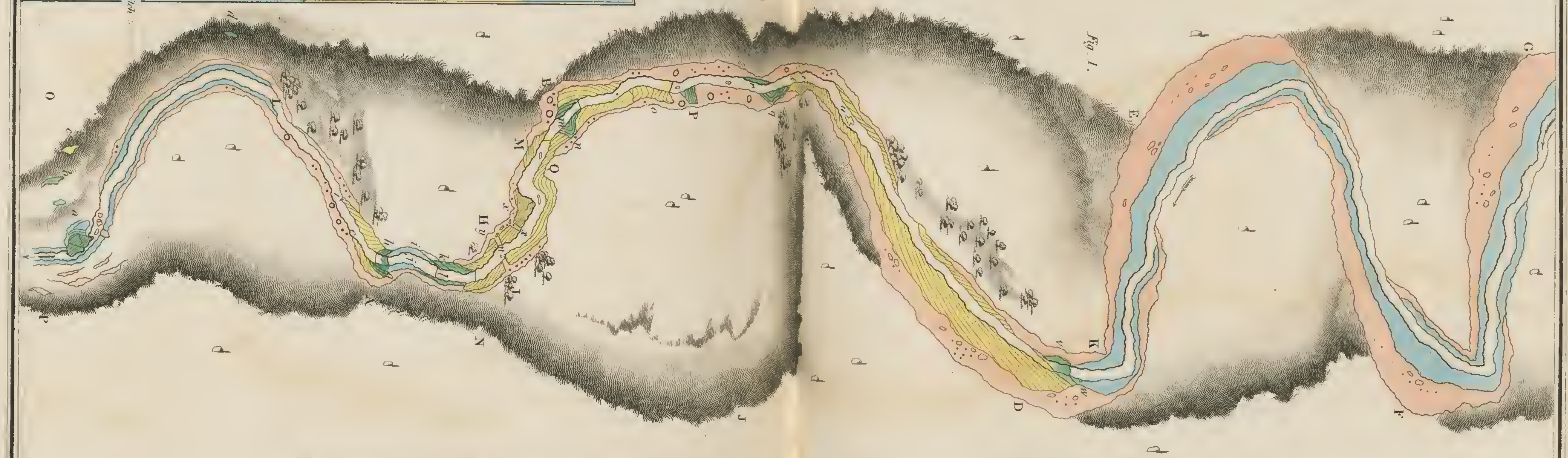
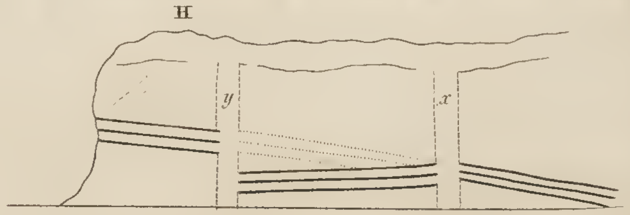


Fig 3, Explanation of the Fissures at Letter H on the Map.

N.B. The Outcrop of the several strata is traced across the stream from bank to bank the colour being made fainter on the side towards which the beds dip.



▨ Diluvian gravel
🟨 Limestone
🟩 Green Clay or Shale
🟦 Blue Clay
Boulders

The coloured lines shew the dip & contortions of the beds as they appear in the cliffs on each side of the stream.

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Engraved by J. Cross, Cursitor Street.

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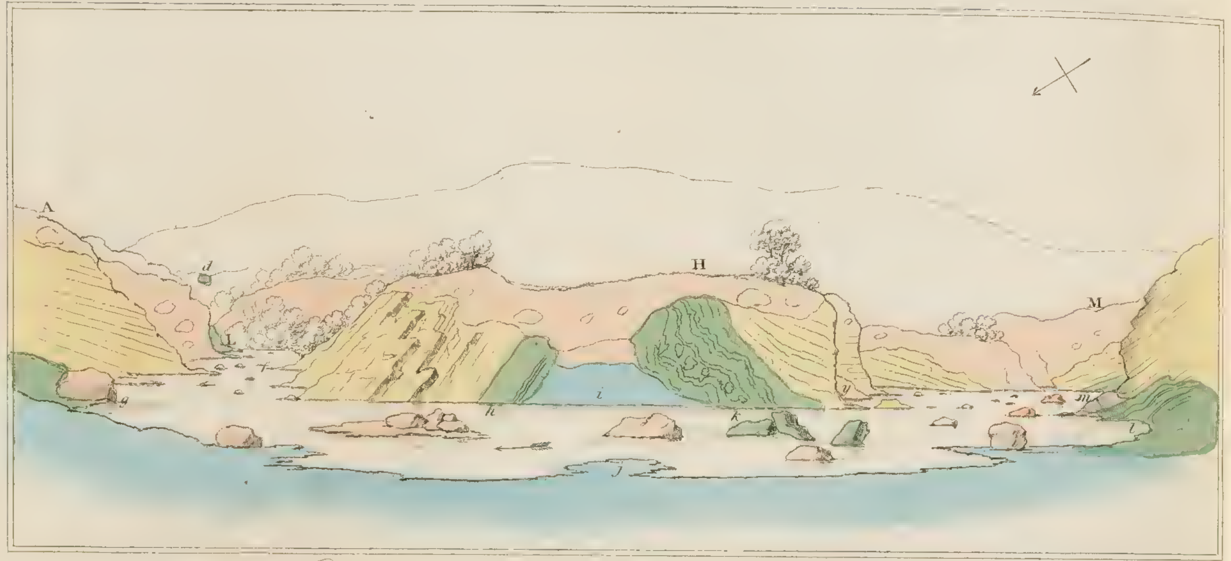
VIEWS on the RIVULET PULCOVCA.

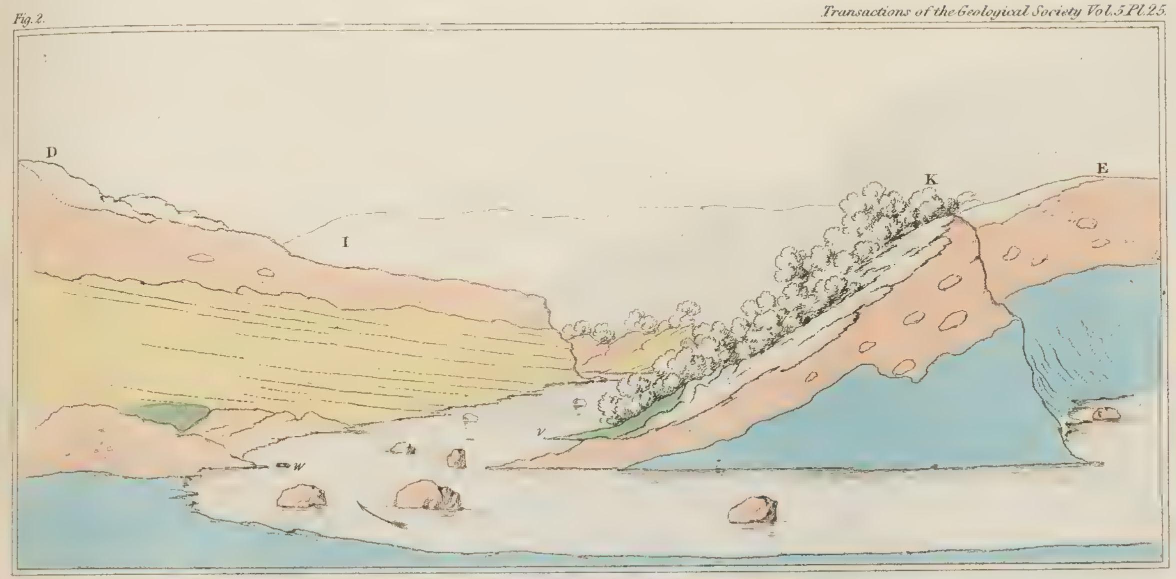
Transactions of the Geological Society Vol. 5 Pl. 25.

Fig. 1.



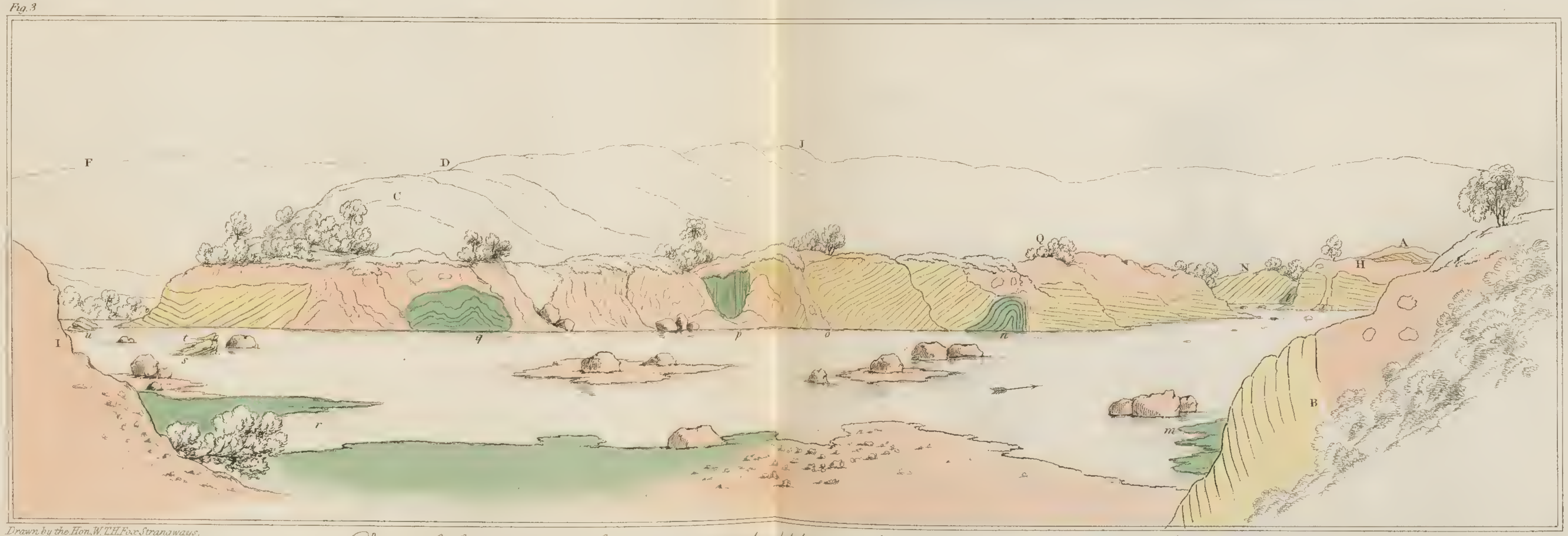
View near the lower extremity of the Outlier.

Fig. 2.



View shewing the upper extremity of the Outlier.

Fig. 3



Drawn by the Hon. W. T. H. Fox Strangways.

View of the strata in the space comprehended between the two points represented in Figs. 1 & 2.

(N.B. the Blue Clay not visible in any part)

- 🟧 Diluvian Gravel
- 🟨 Limestone
- 🟩 Green Clay or Shale
- 🟦 Blue Clay

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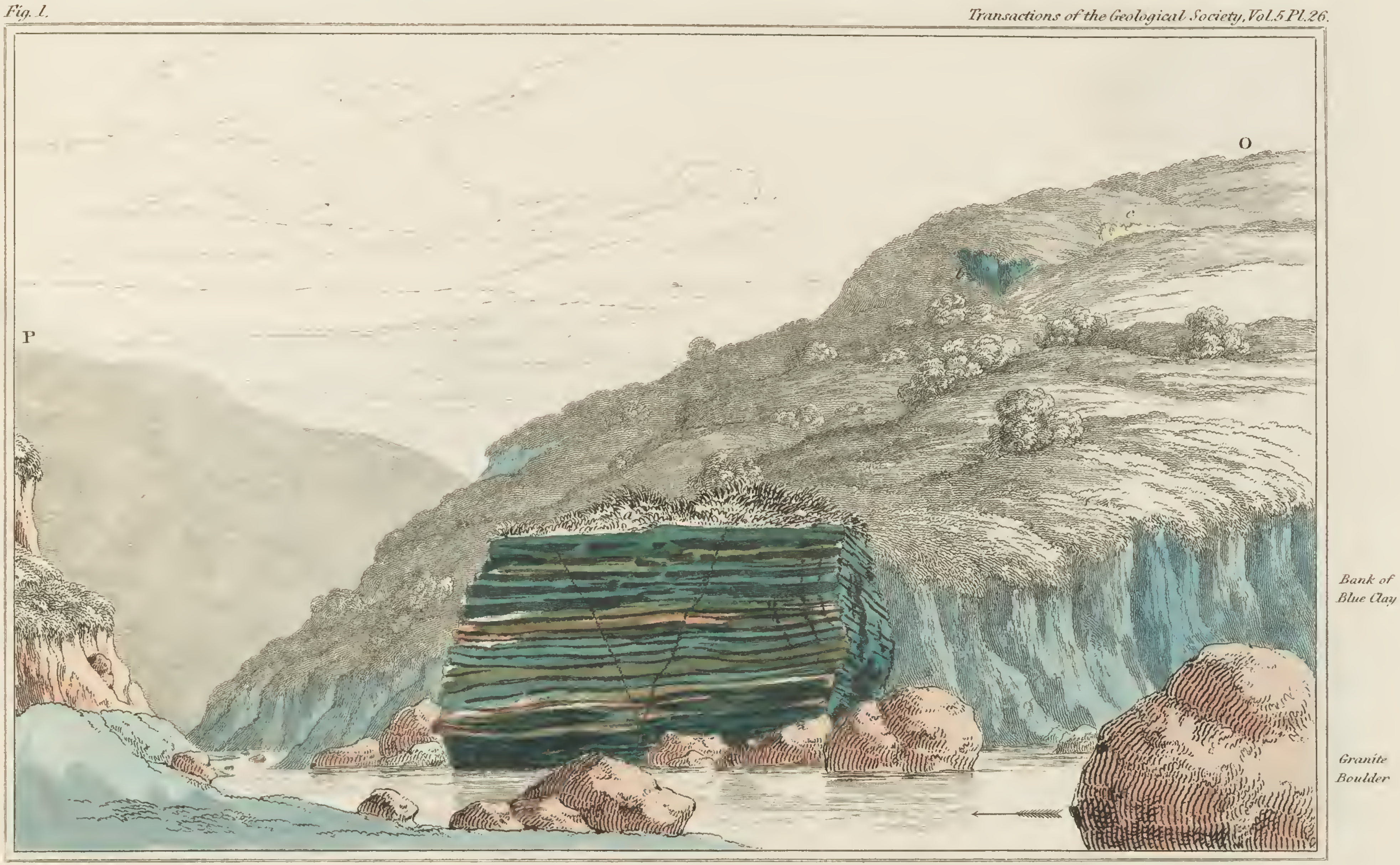
Fig. 1.

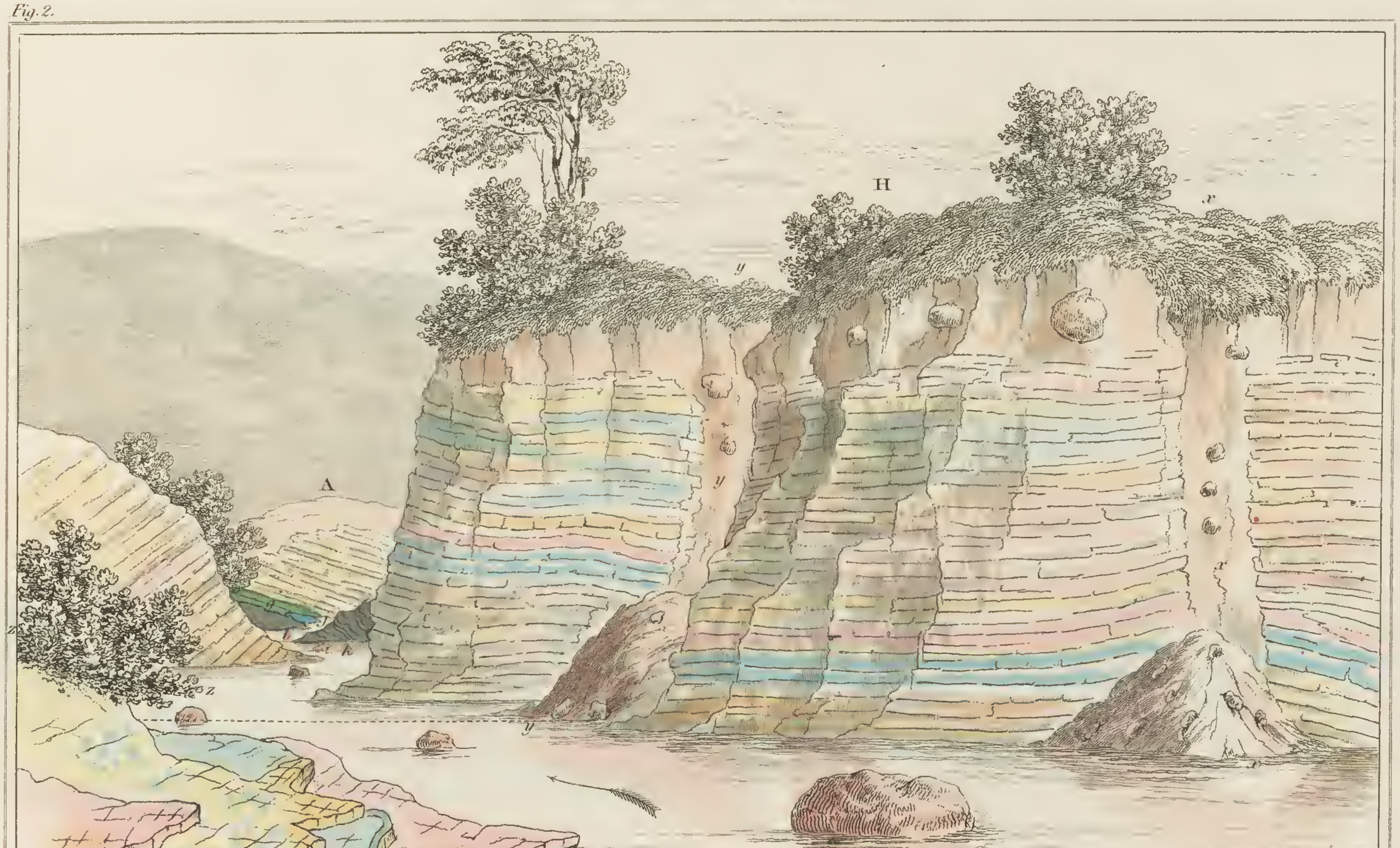


Landslip of the dark green clay on the right bank of the Pulcovca.

(N.B. This spot is marked a. in the Plan and Section.)

In this Plate, the Boulders are all masses of primitive rock.

Fig. 2.



Drawn by the Hon. W. T. H. Fox Strangways.

View down the Pulcovca, shewing the variety of colour of the limestone strata, the dykes filled with diluvium on the right, and the natural pavement and tendency to cubic fracture on the left.

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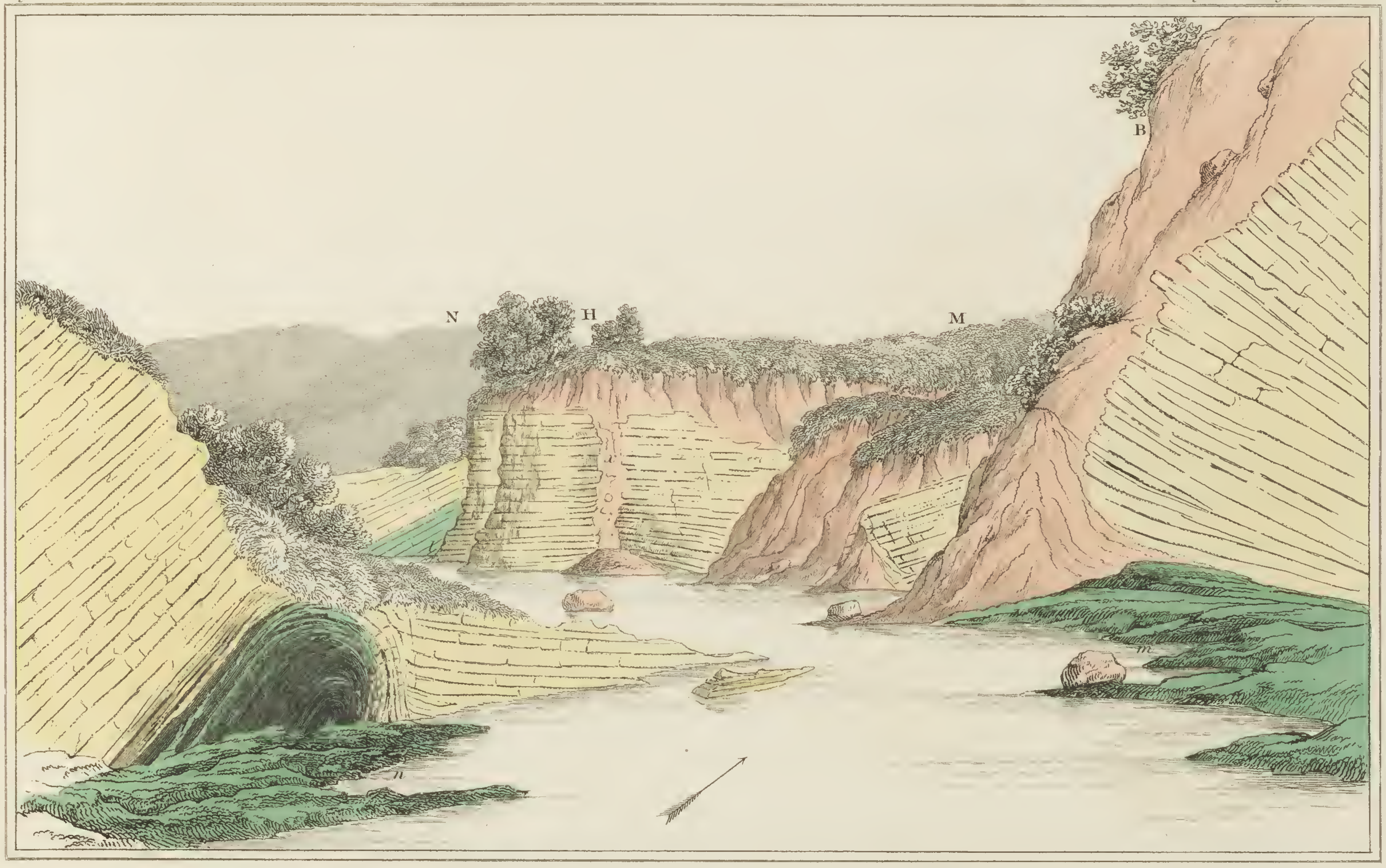
Irregularities of the strata on the Pulcovca

Fig. 1.



SECTIONS of the PULCOVCA OUTLIER.

Fig. 2.

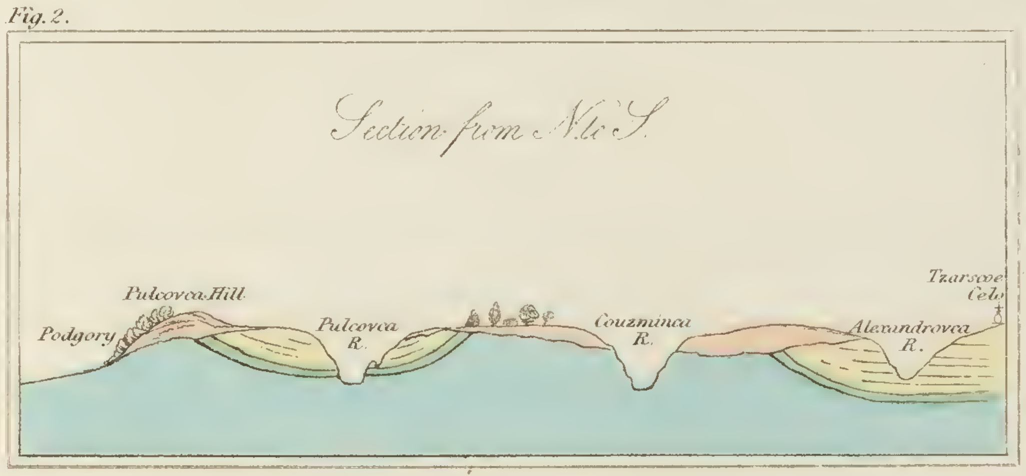
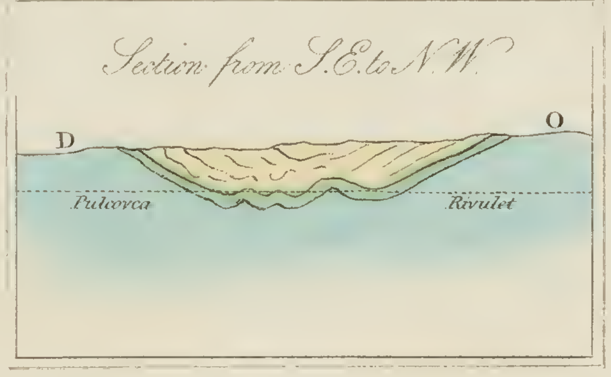
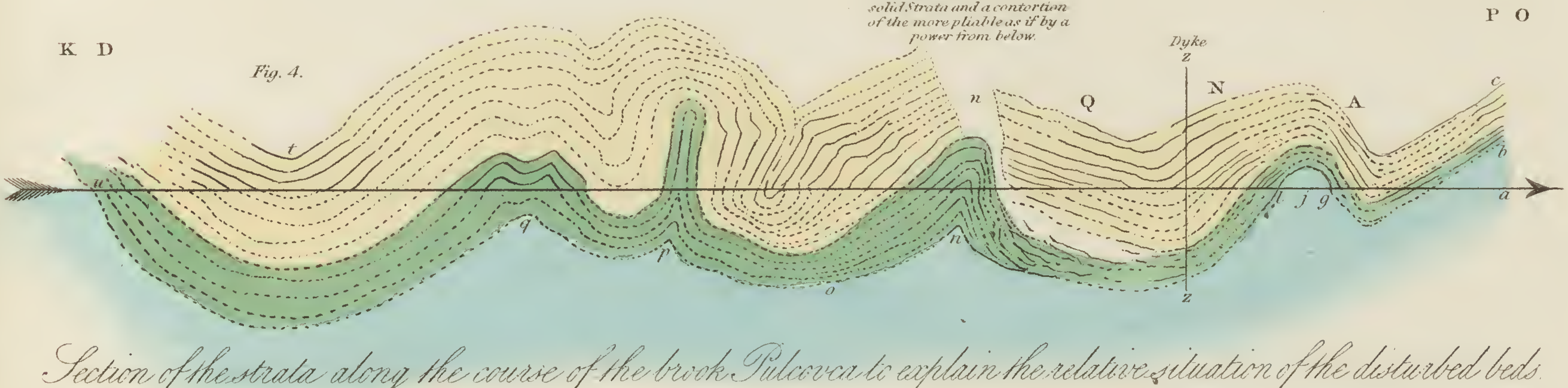

Section from N. to S.

Fig. 3.


Section from S.E. to N.W.


n. Here appears to have been a forcible disruption of the solid Strata and a contortion of the more pliable as if by a power from below.

Section of the strata along the course of the brook Pulcovca to explain the relative situation of the disturbed beds.

As the general course of the Pulcovca here differs little from a straight line, u.—a. will represent its level with sufficient exactness. The horizontal distances are shortened.

≡ Strata now visible. ┄ Supposed continuation.

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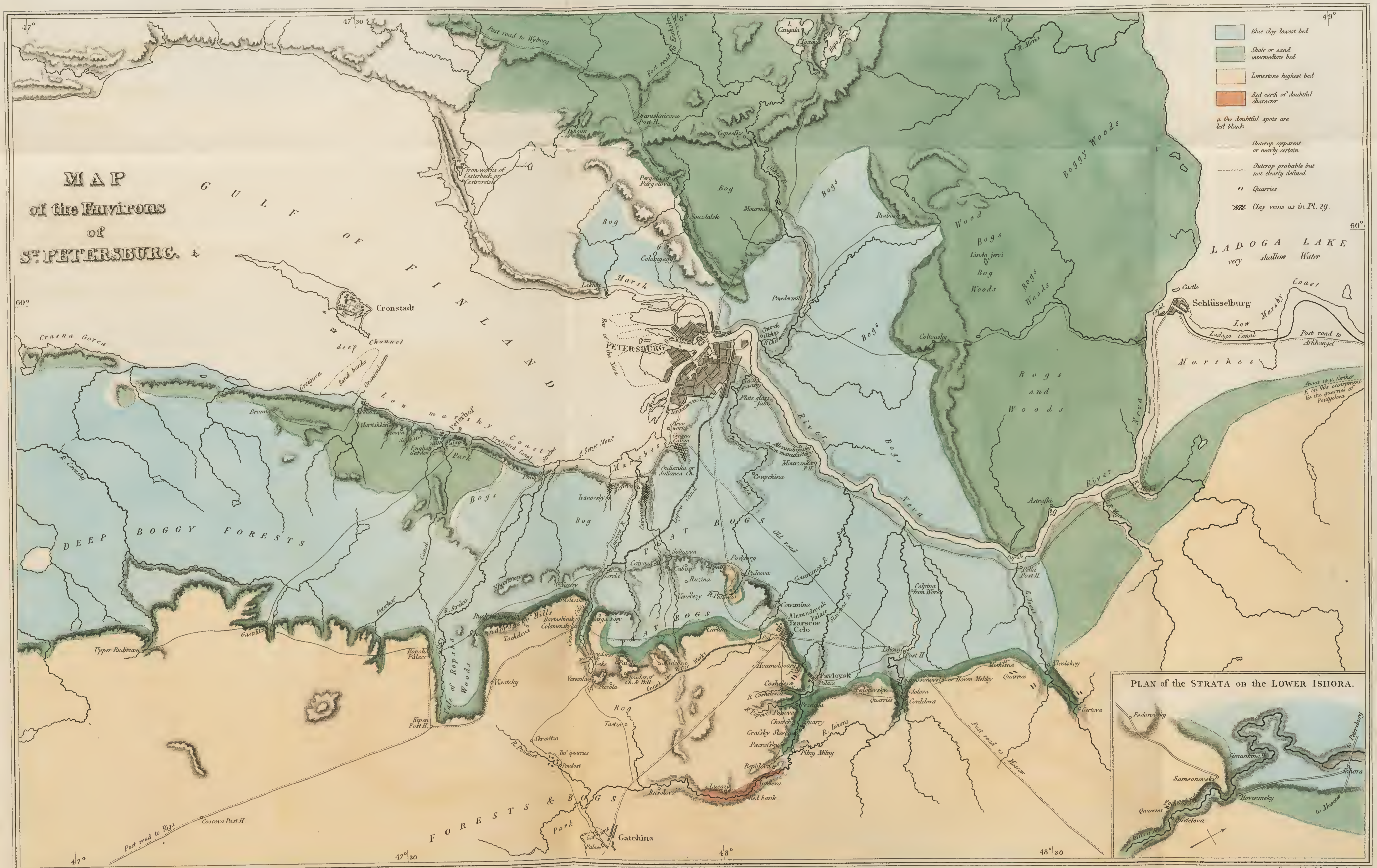

MAP of the Environs of St. PETERSBURG.

Drawn by The Honble W. T. H. Fox Strangways.

Engraved by J. Cross, Cursitor Street.

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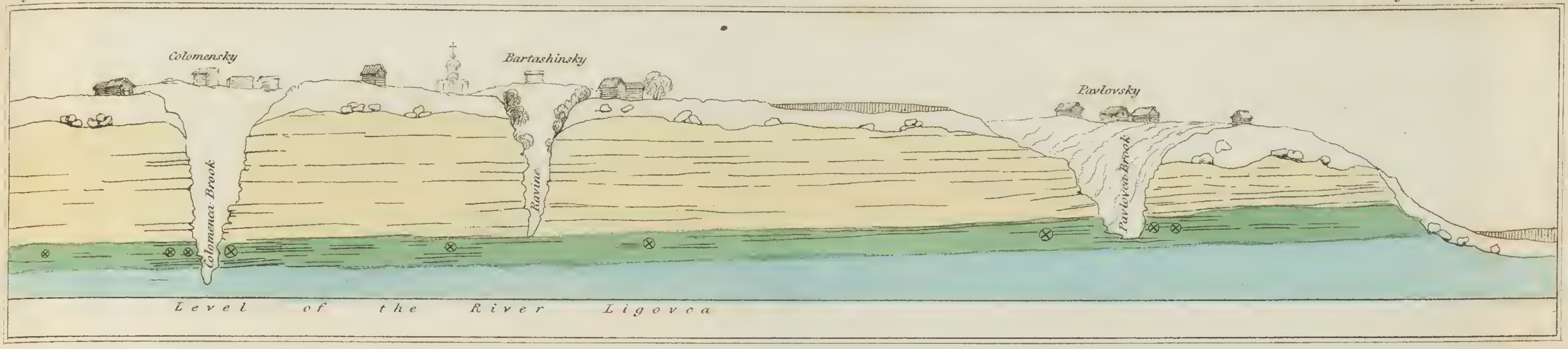
Section of the heights of Crasnoe Celo from N.E. to S.W.

Fig. 1.



1 ▥ Bog.

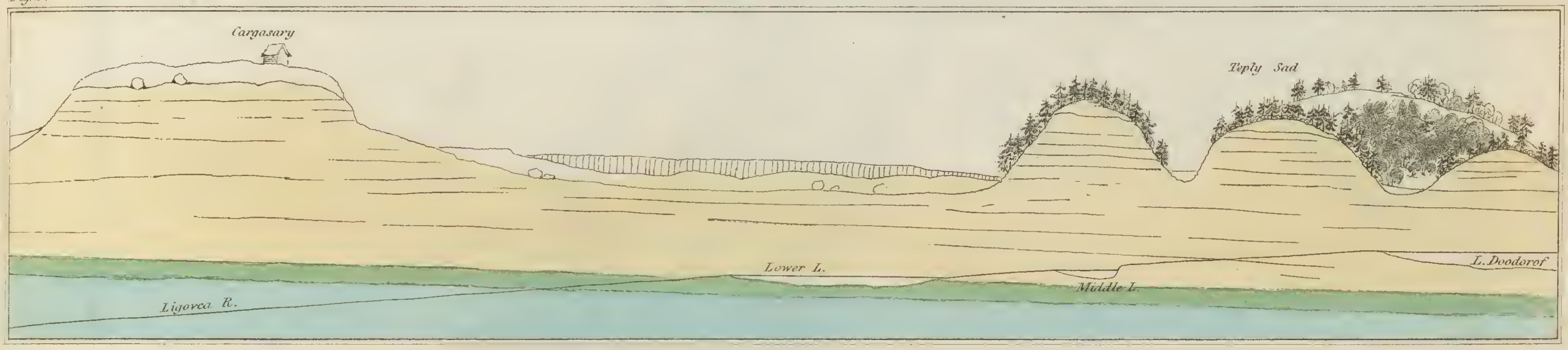
2 Diluvian Gravel with Primitive Boulders.

3 Limestone.

4 ⊗ Bituminous Shale with Concretions of Stink Stone and Pyrites.

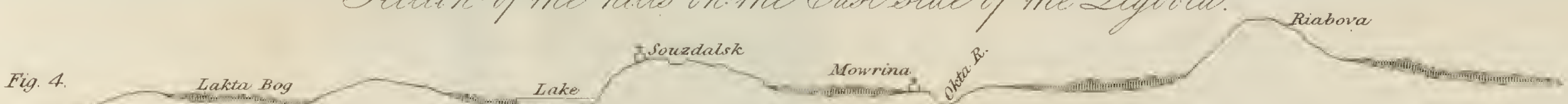
5 Clay.

Fig. 2.



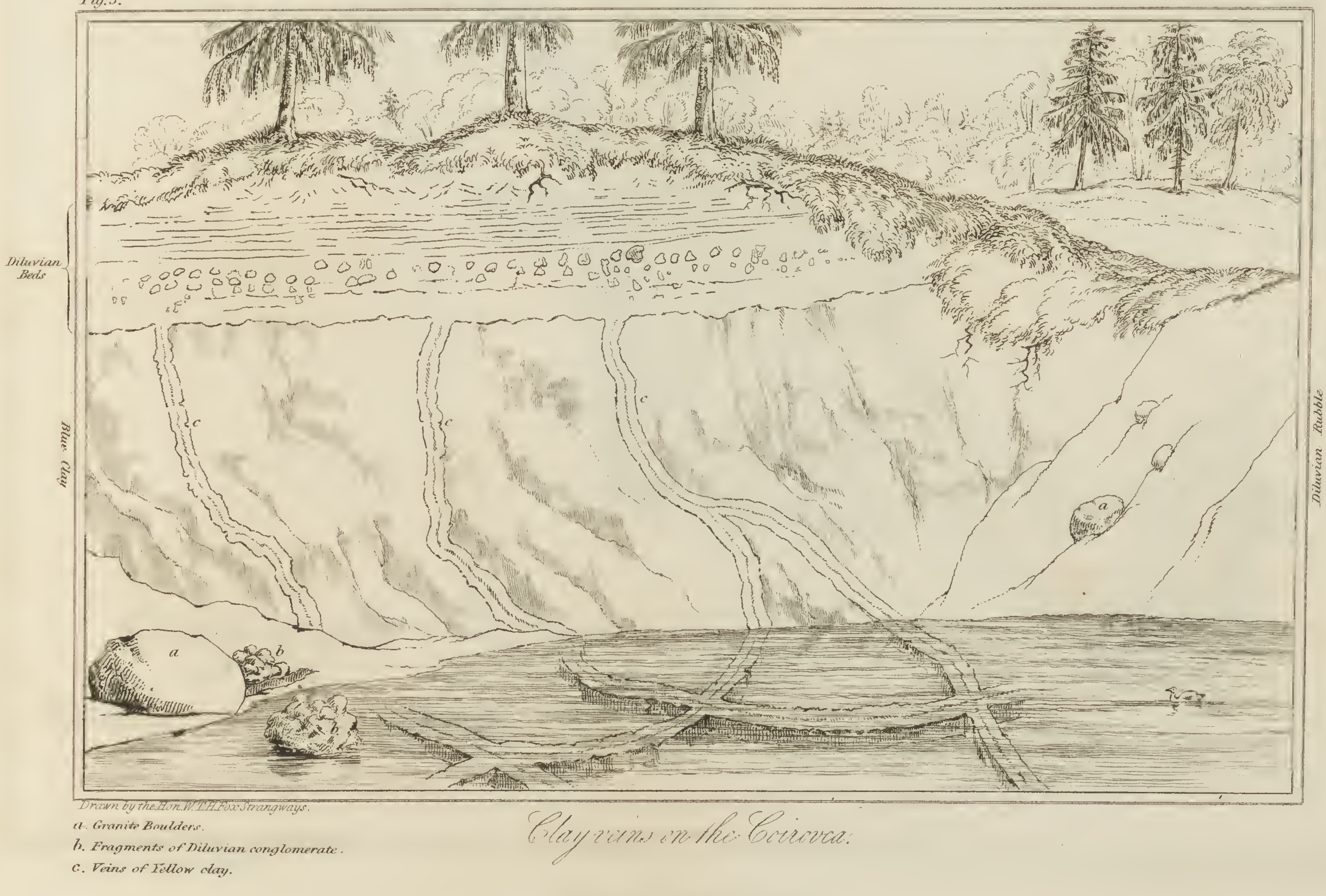
Section of the hills on the East side of the Ligovca.

Fig. 4.



Section of the country on the right bank of the Neva.

Fig. 3.



Drawn by the Hon. W. T. H. Fox Strangways.

a. Granite Boulders.

b. Fragments of Diluvian conglomerate.

c. Veins of Yellow clay.

Clay veins on the Coirovca.

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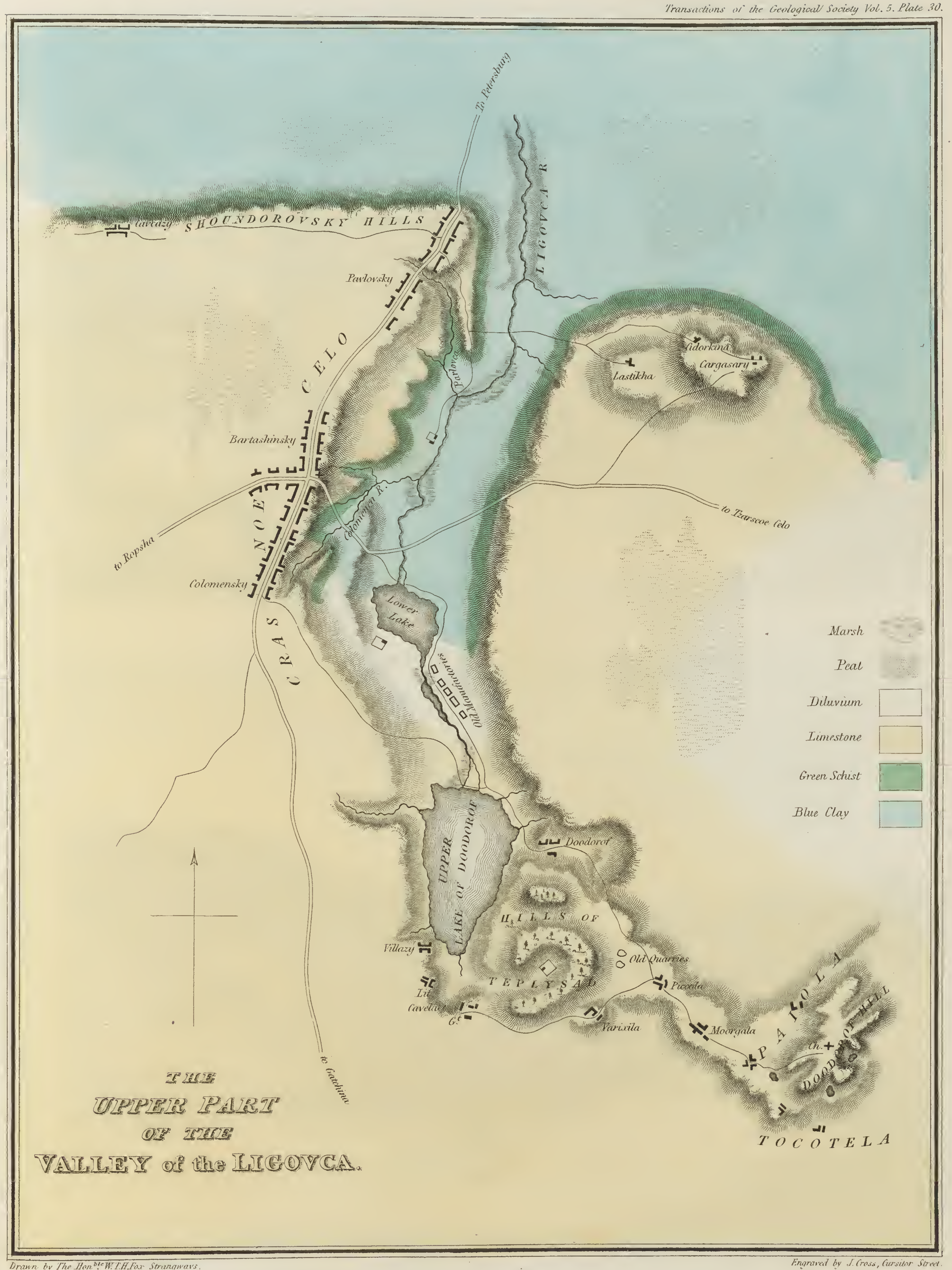

THE
UPPER PART
OF THE
VALLEY of the LIGOVCA.

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Engraved by J. Cross, Cursitor Street.

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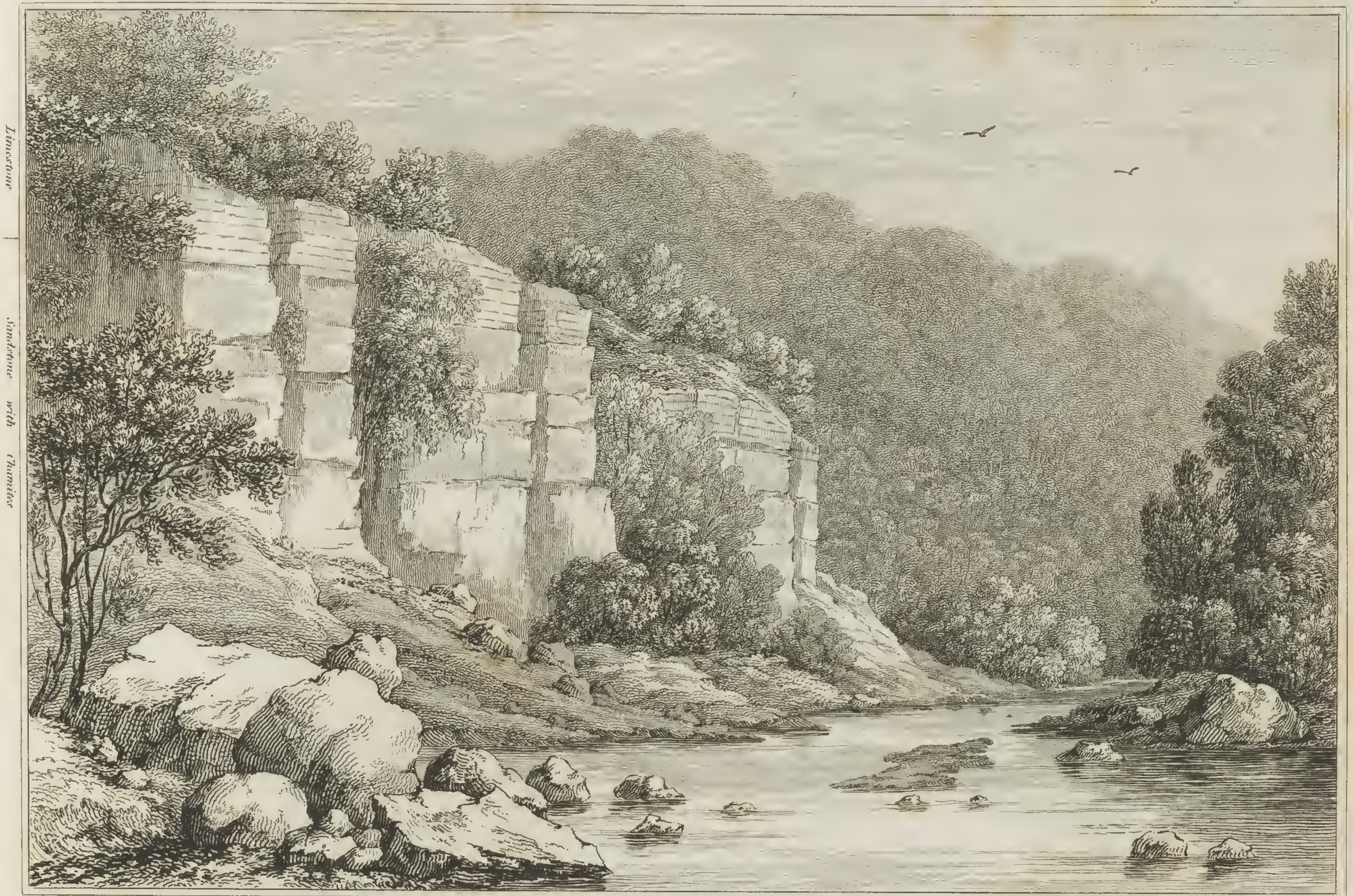
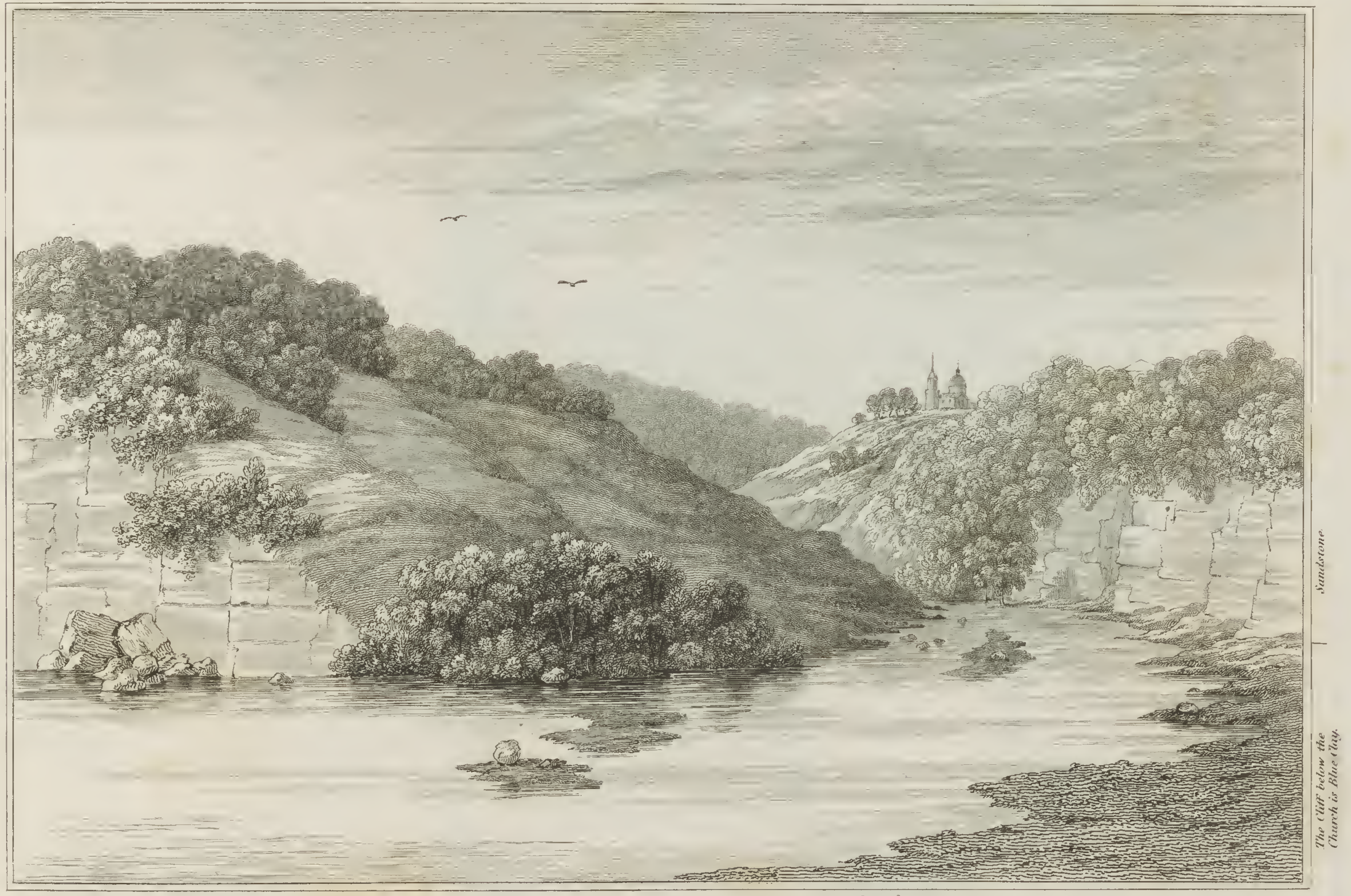
Fig. 1.



View near Gertova on the right bank of the Tosna.

Fig. 2.


Sandstone
The Cliff below the Church is Blue Clay.

Drawn by the Hon. W. T. H. Fox Strangways.

View of Nicolscoy on the right bank of the Tosna.

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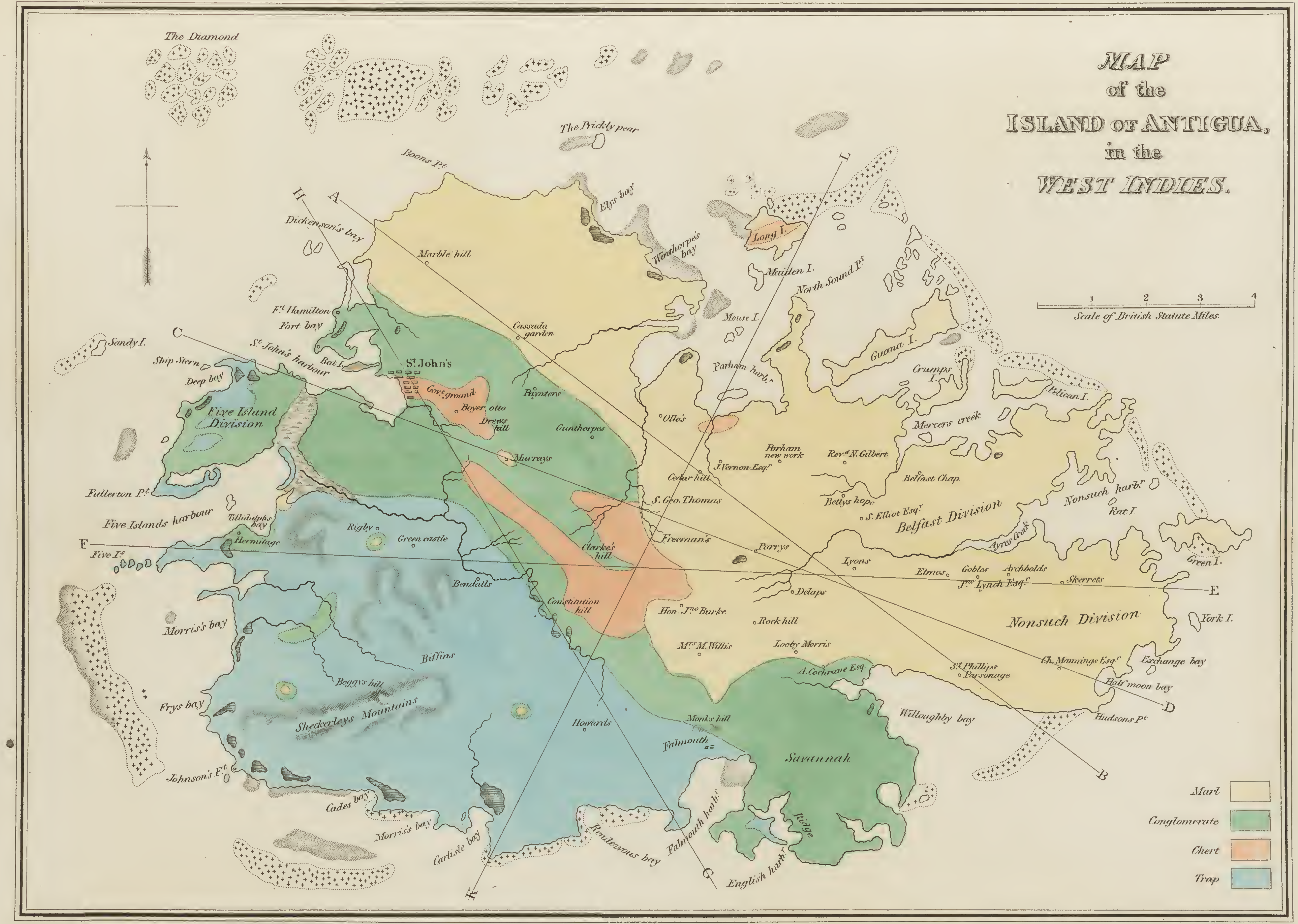
MAP
# of the
ISLAND OF ANTIGUA,
in the
WEST INDIES.



Crofs. Sc. 12, Cursitor Street.

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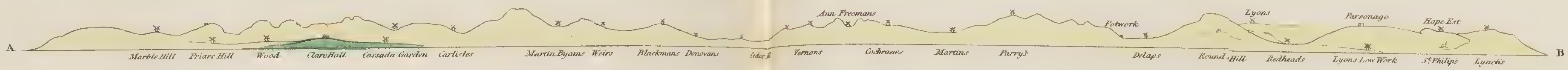
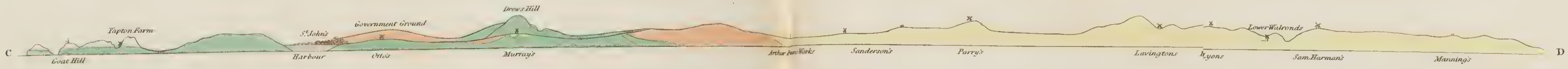
Fig



Fig



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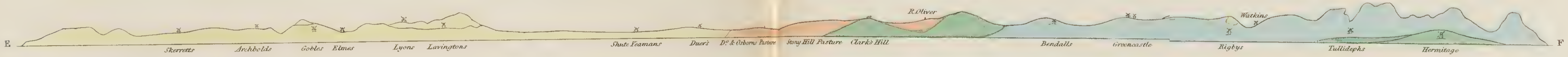

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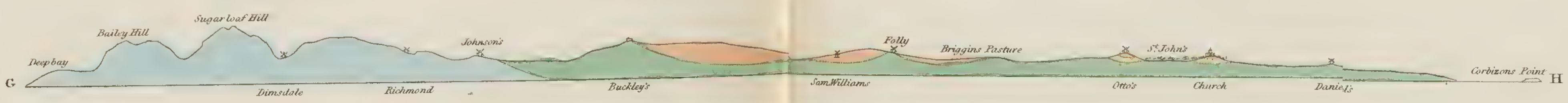

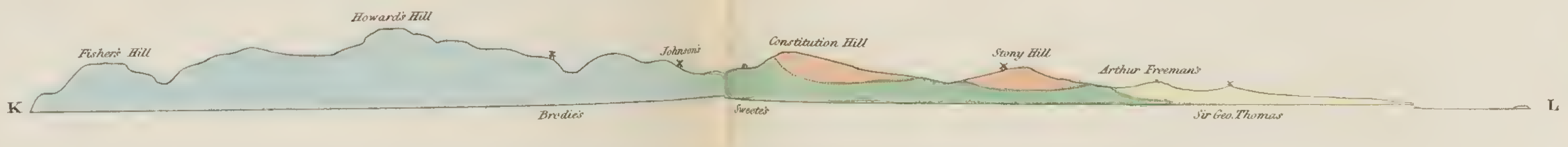

🟨 Marl
🟩 Conglomerate
🟧 Chert
🟦 Trap

Sections of the island of Antigua, the lines of direction see the Map.

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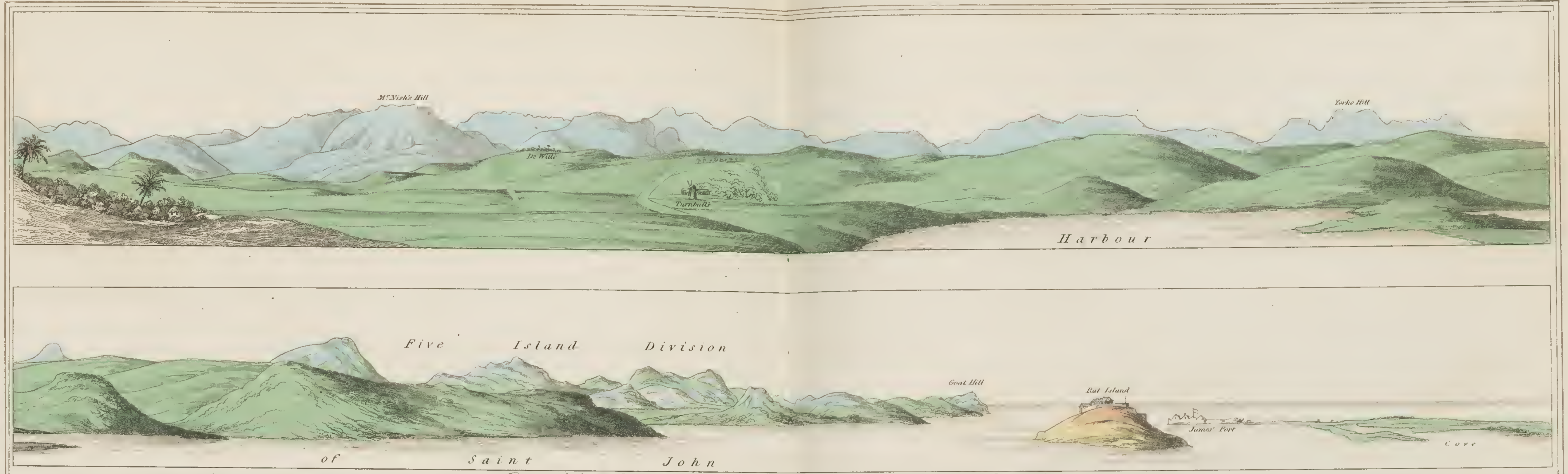
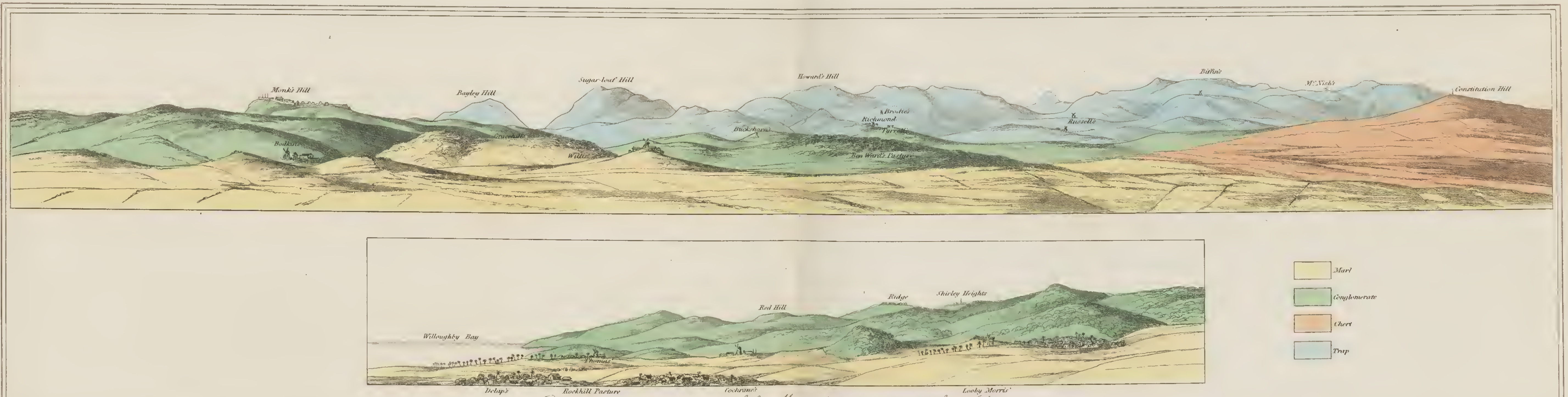


View of the Westward part of the Mountain range taken from St. Johns Steeple.



View of the Eastward part of the Mountain range taken from Parry's.

Drawn by Nicholas Nugent Esqr.

VIEWS in the ISLAND of ANTIGUA.

Coloured geologically.

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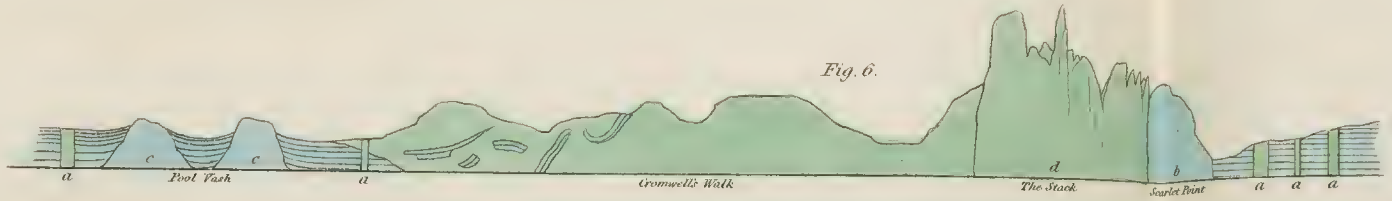
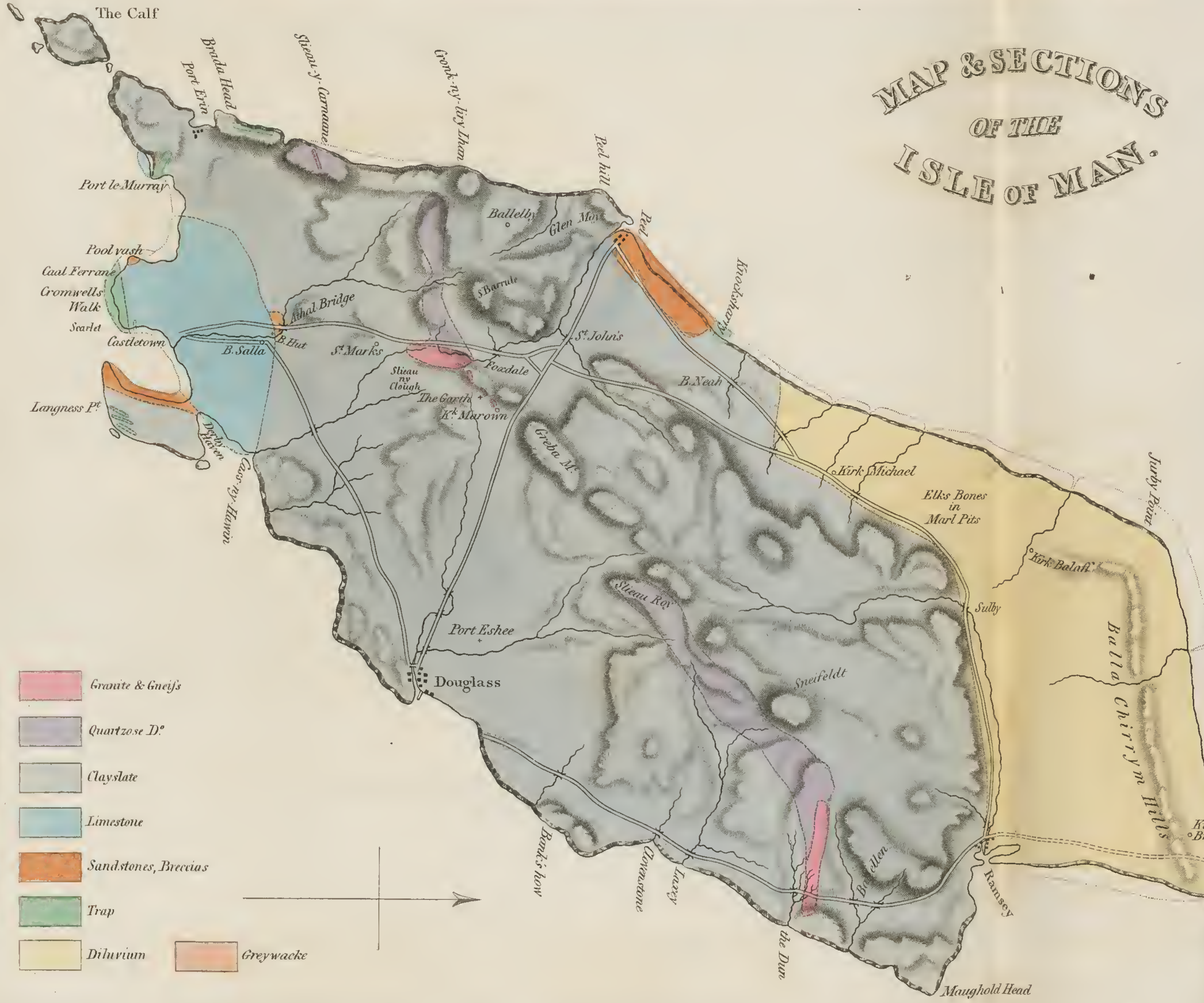
Fig. 6.



MAP & SECTIONS OF THE ISLE OF MAN.



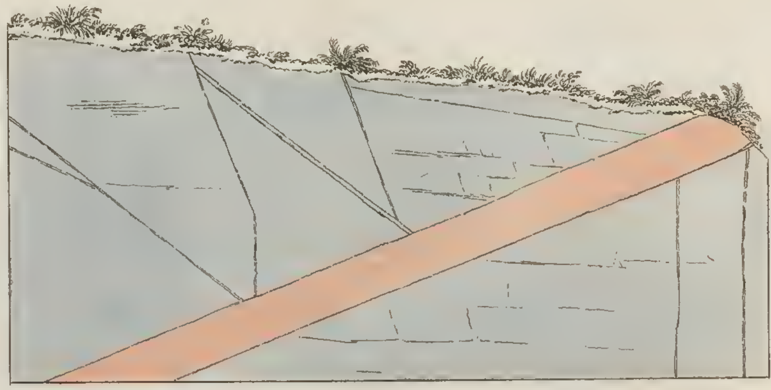


Fig. 1.

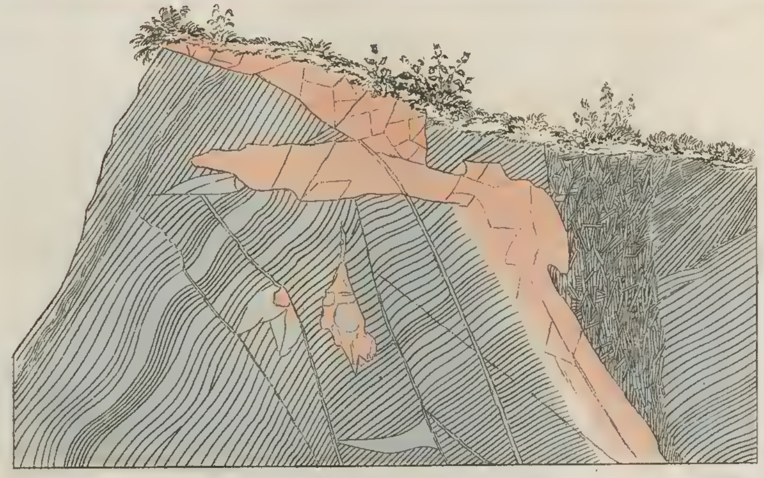


Fig. 2.

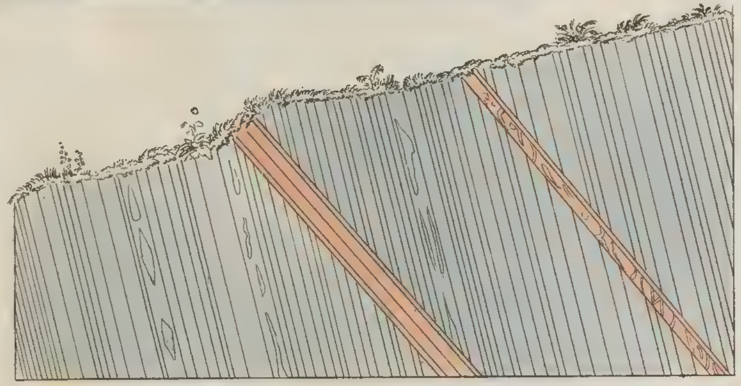


Fig. 3.

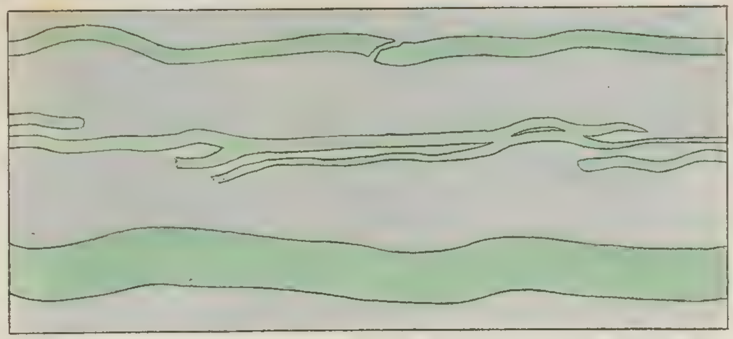


Fig 4.

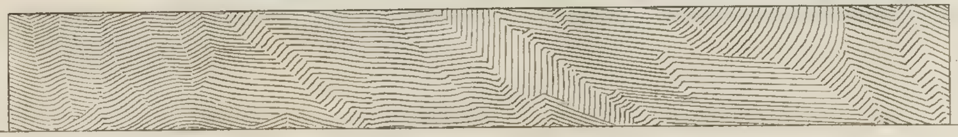


Fig. 5.

Drawn by J.S. Henslow

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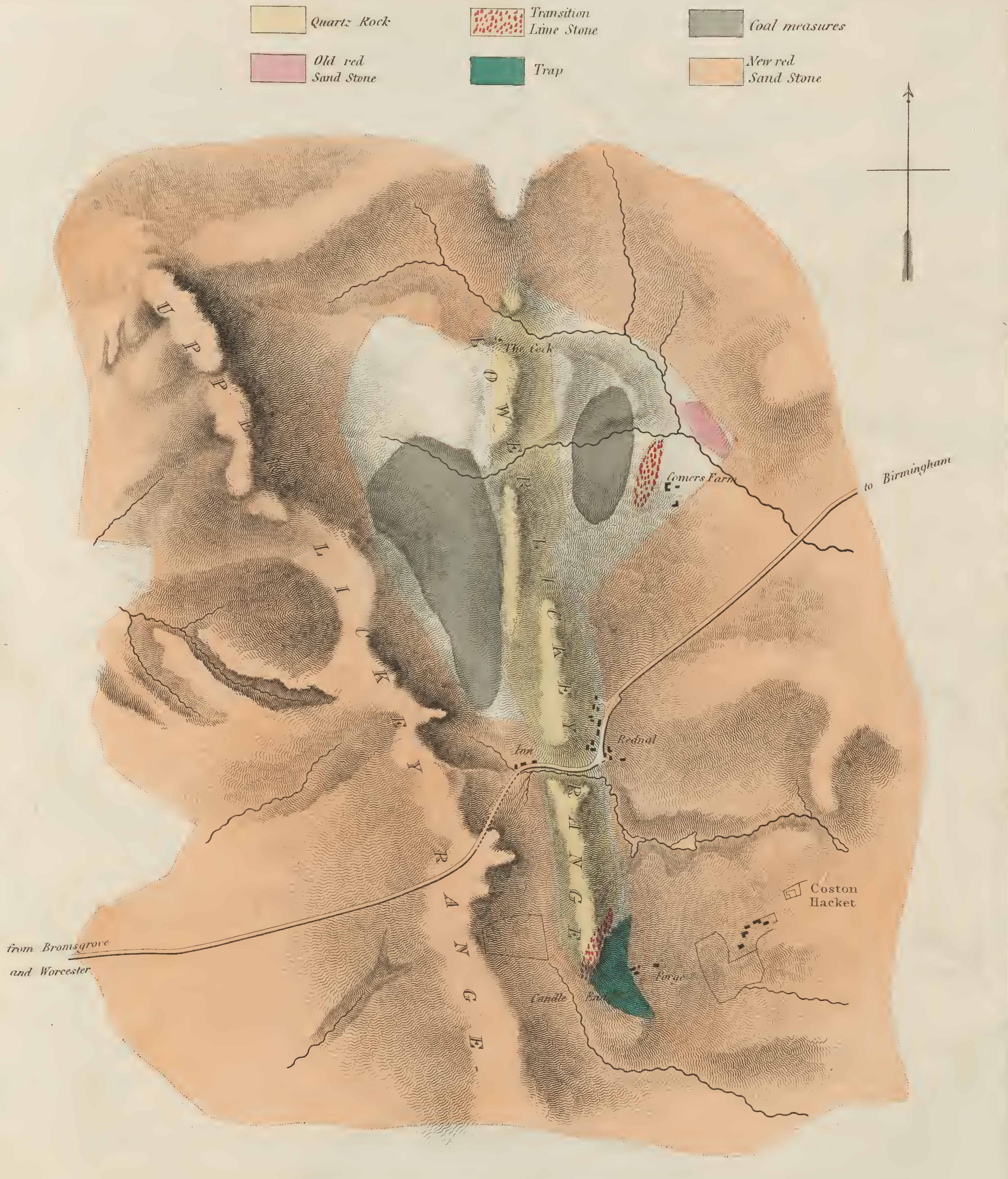

MAP of the LICKEY HILLS in WORCESTERSHIRE.

1/2 1 Mile

J. Cross sculp^t. 12 Cursitor St.

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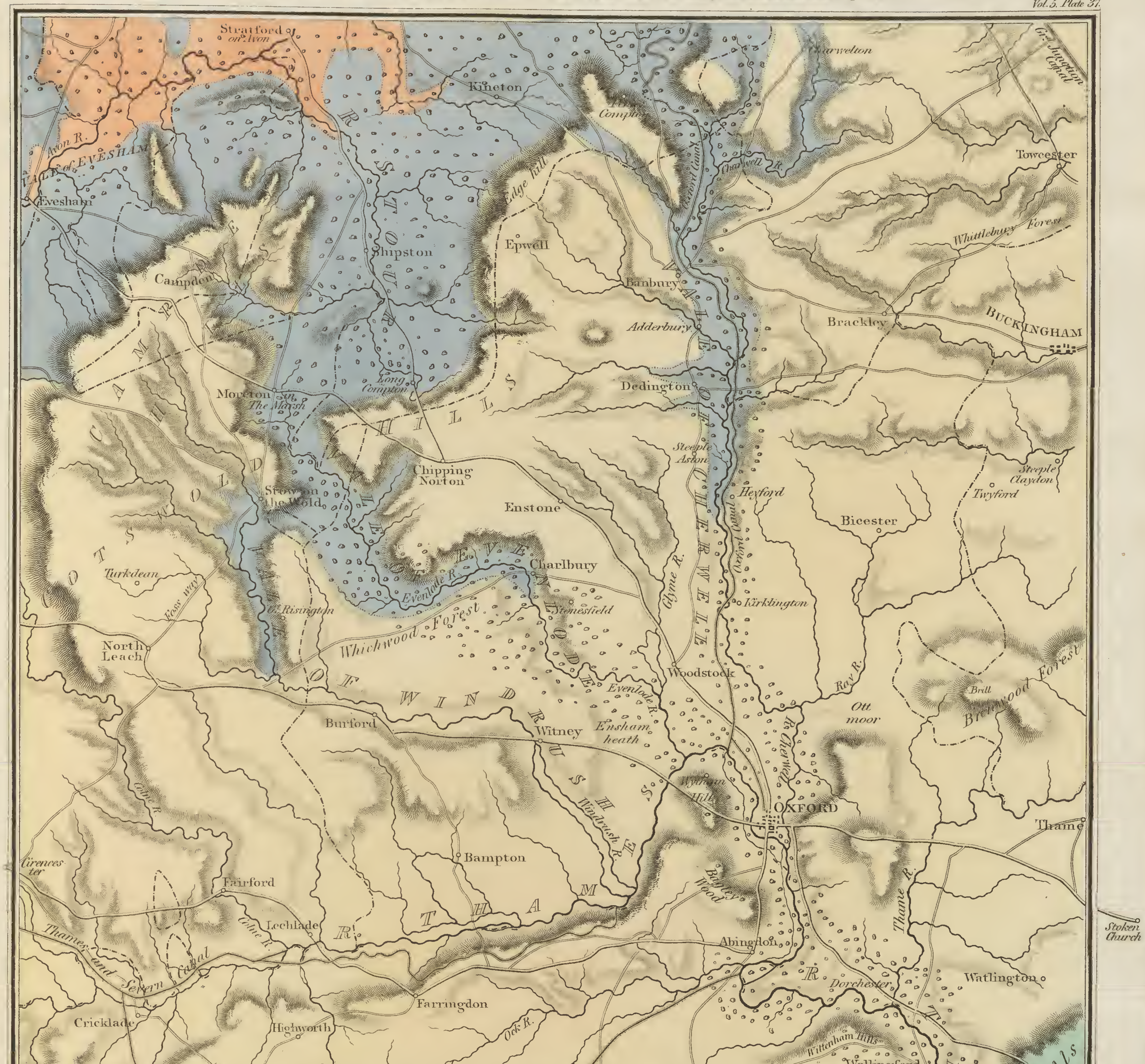
MAP of the VALE of the EVENLODE, THAMES, &c.

Transactions of the Geological Society
Vol. 5. Plate 37.



J. Cross sculpt. 12 Cursitor St.

Chalk	🟩
Green Sand and Oolite formations	🟨
Lias	🟦
Red Marl of new red sand stone formation	🟧
Gravel containing pebbles of Quartz Rock.	⁘

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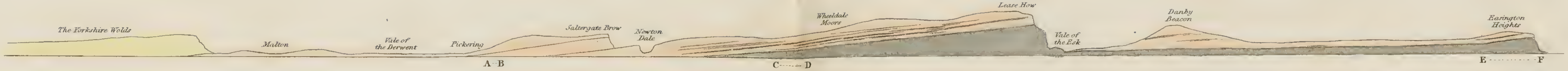
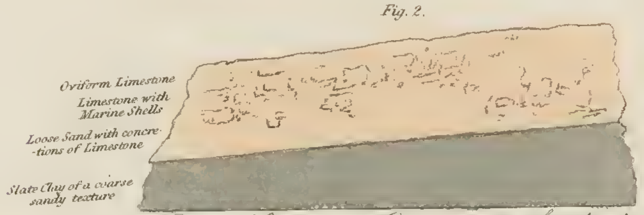
Fig. 1.



Section across part of Yorkshire, to accompany Mr. Winch's paper.

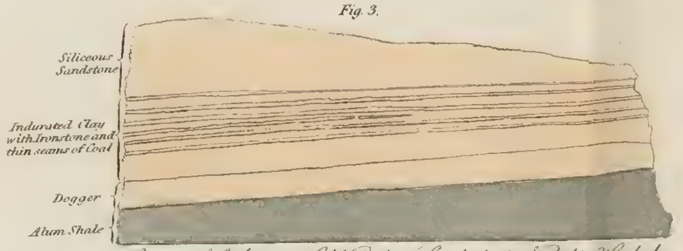
Fig. 2.


Oviform Limestone
Limestone with Marine Shells
Loose Sand with concre-tions of Limestone
Slate Clay of a coarse sandy texture

Rock at Scarborough Castle about 300 f.t in height.
see A · B Fig. 1.

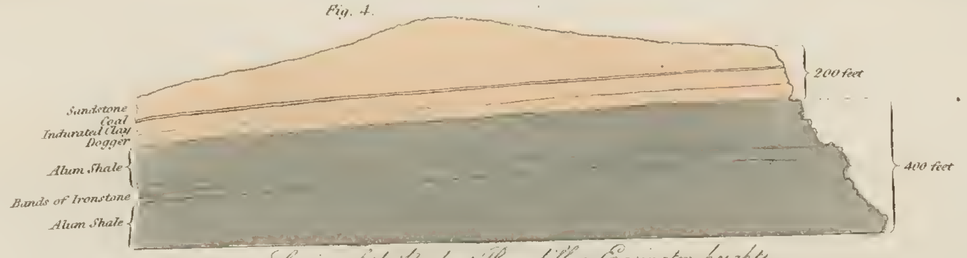
These Strata continue westwards by Pickering, Kirby, & Helmsley, as far as Hambleton.

Fig. 3.



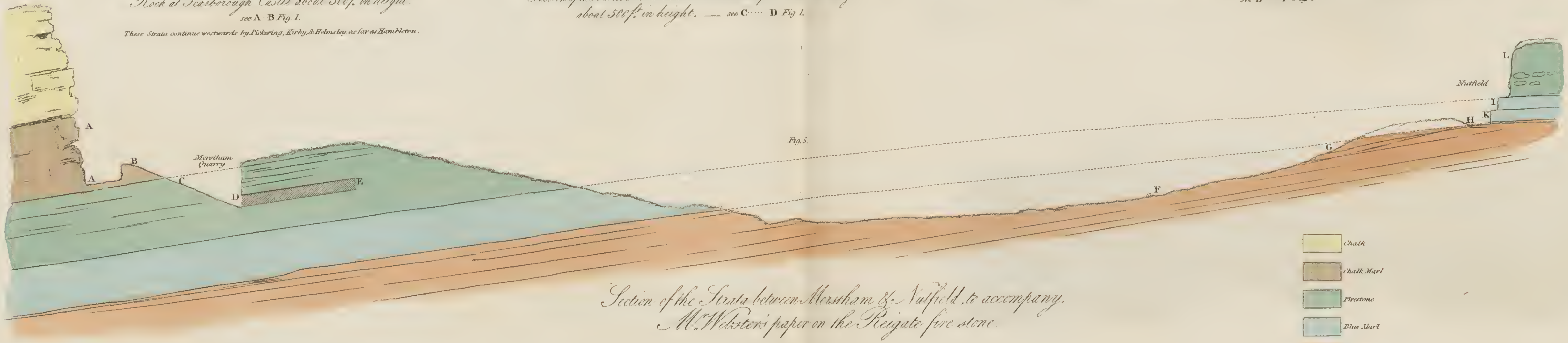
Section of the Rock at Old Peak or South cheek of Robin Hoods bay about 500 f.t in height. — see C····· D Fig 1.

Fig. 4.



Section of the Rock at Rawcliff or Easington heights.
see E-- -F Fig 1.

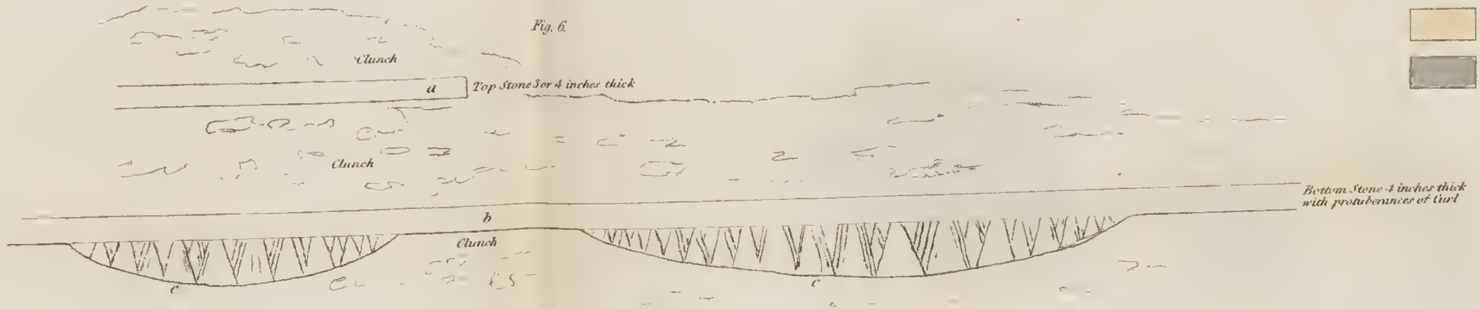
Fig. 5.



Section of the Strata between Merstham & Nutfield, to accompany Mr. Webster's paper on the Reigate fire stone.

🟨 Chalk
🟫 Chalk Marl
🟩 Firestone
🟦 Blue Marl
🟧 Ferruginous Sand
▢ Oolite
▩ Alum Shale

Fig. 6.


Clunch
a
Top Stone 3 or 4 inches thick
Clunch
Bottom Stone 4 inches thick with protuberances of Curl
b
Clunch
c
c

Curl of Staffordshire, to accompany Mr. Yates's paper on that substance.

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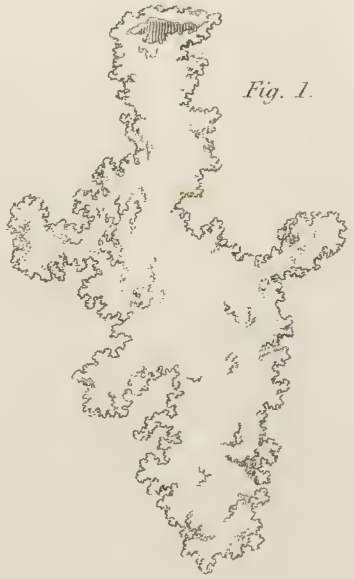
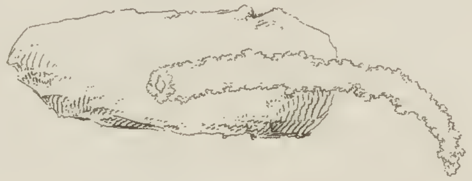


Fig. 1.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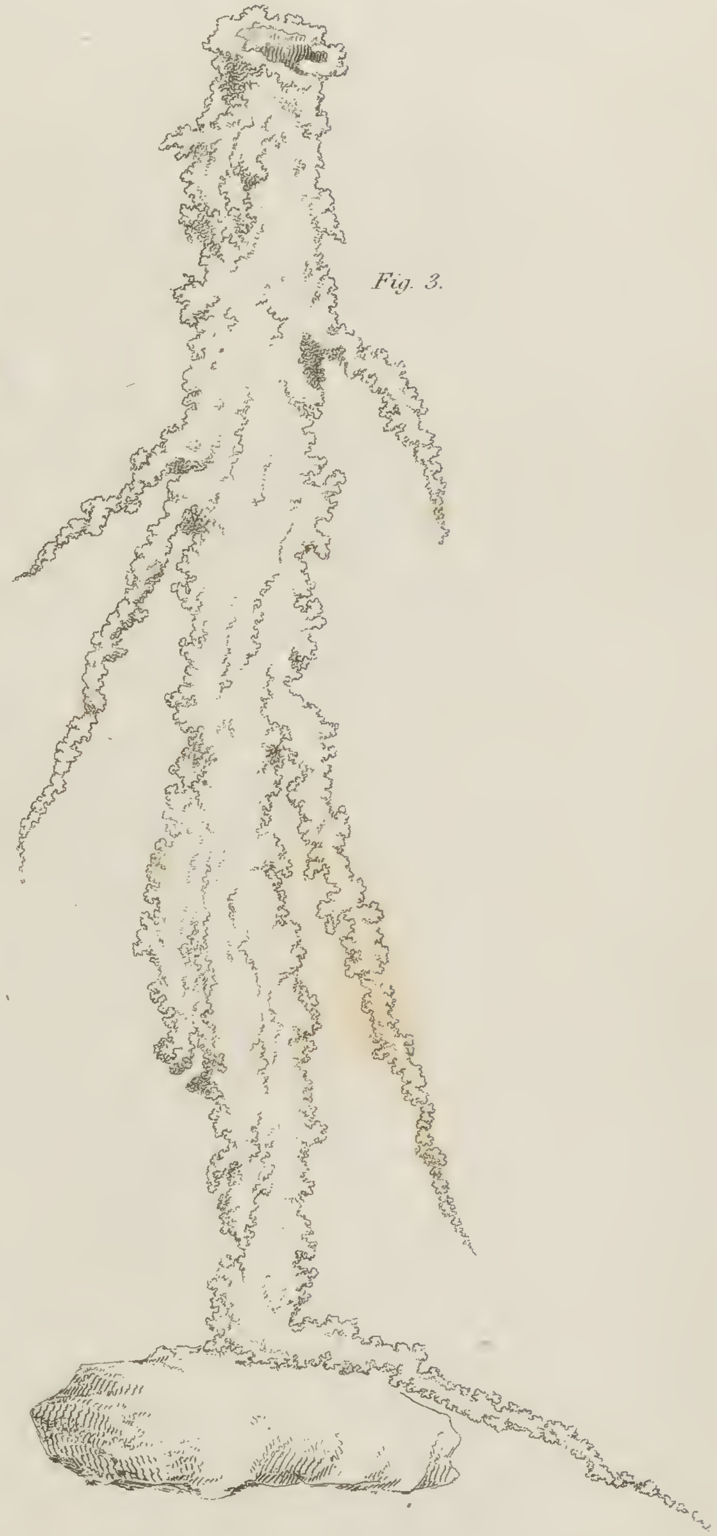
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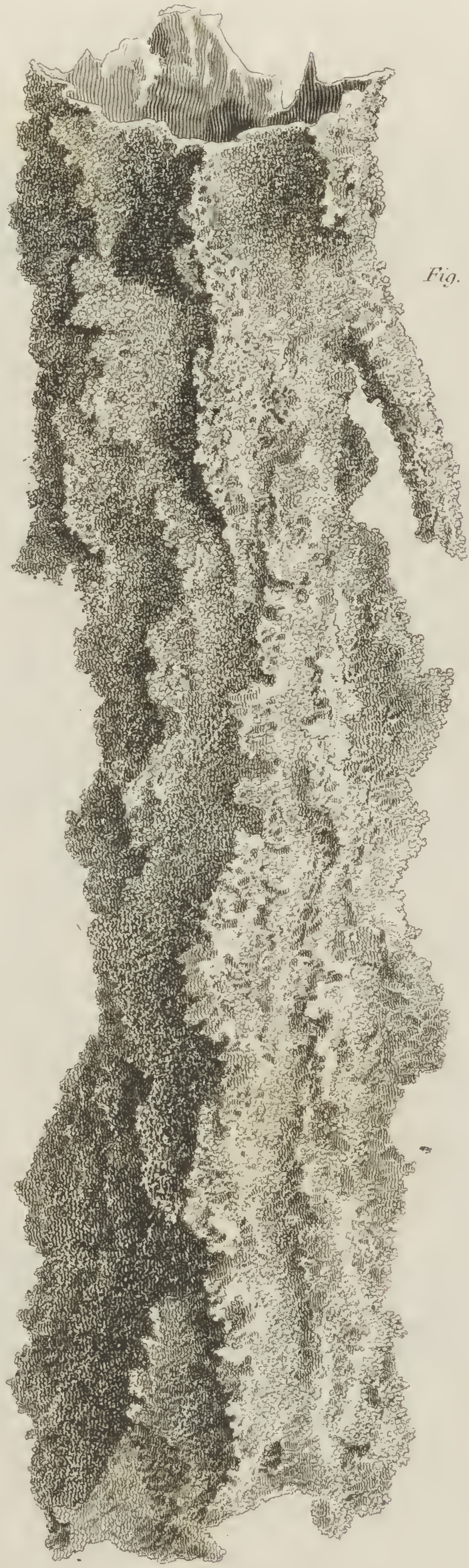
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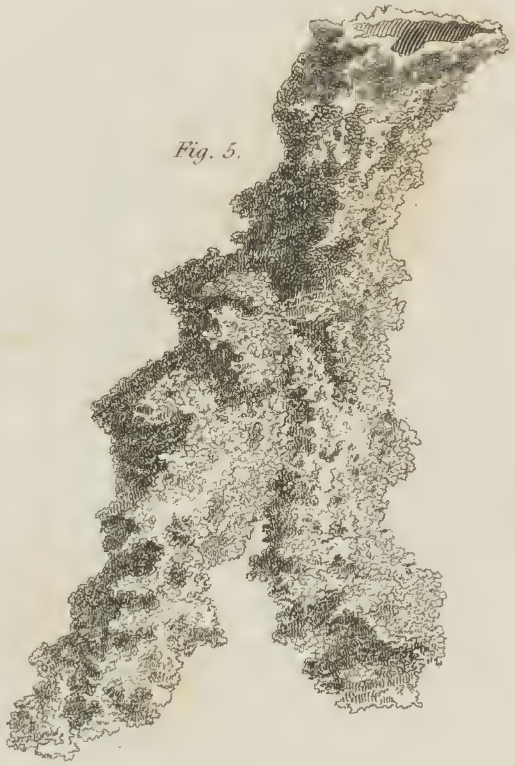
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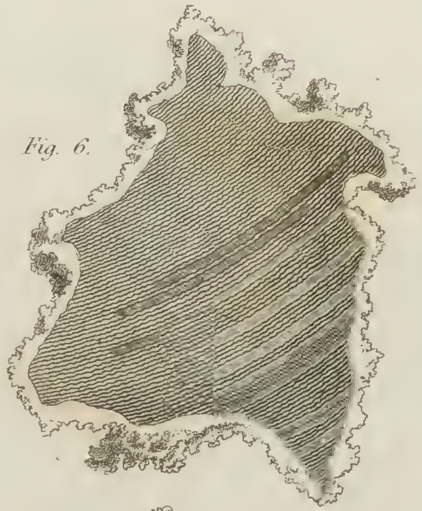
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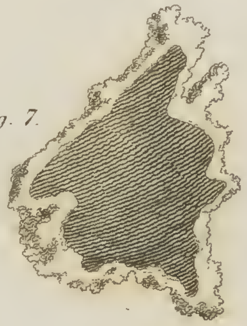
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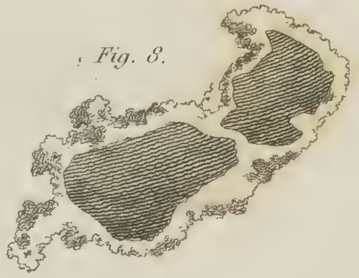
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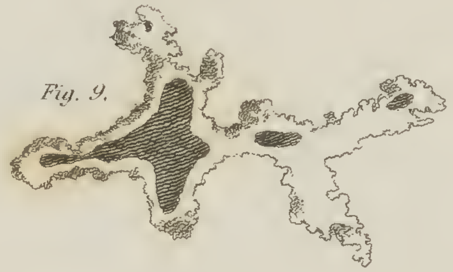
Fig. 9.

Drawn by Thos. Webster.

Vitreous Sand tubes formed at Drigg in Cumberland.

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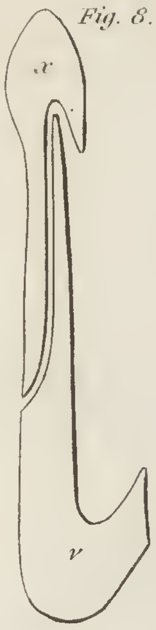
Fig. 8.



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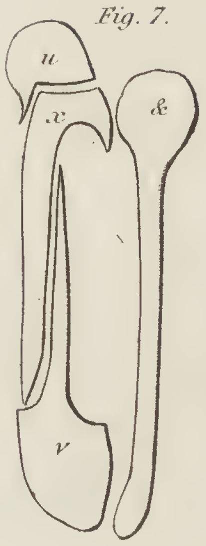

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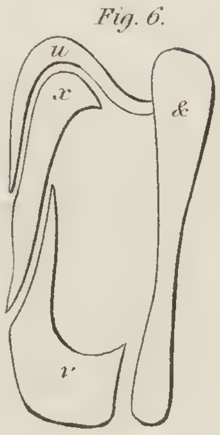

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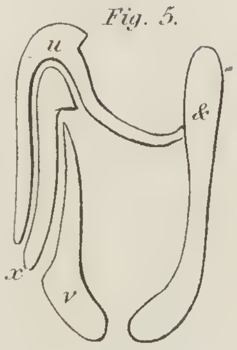

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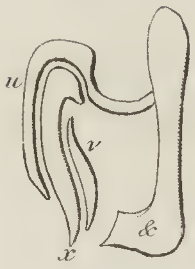

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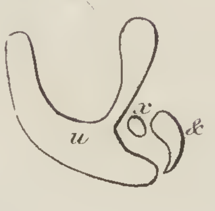

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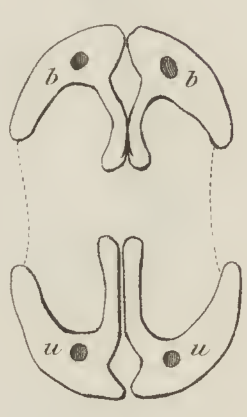

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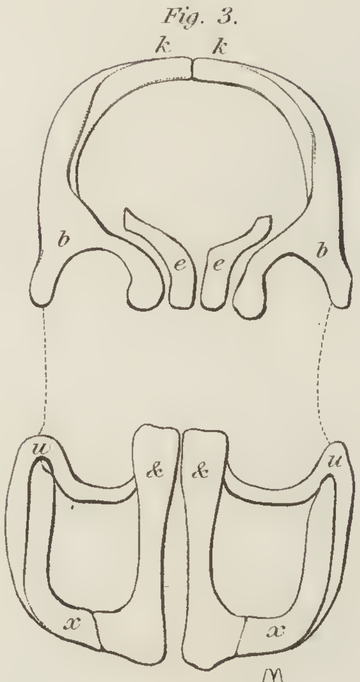

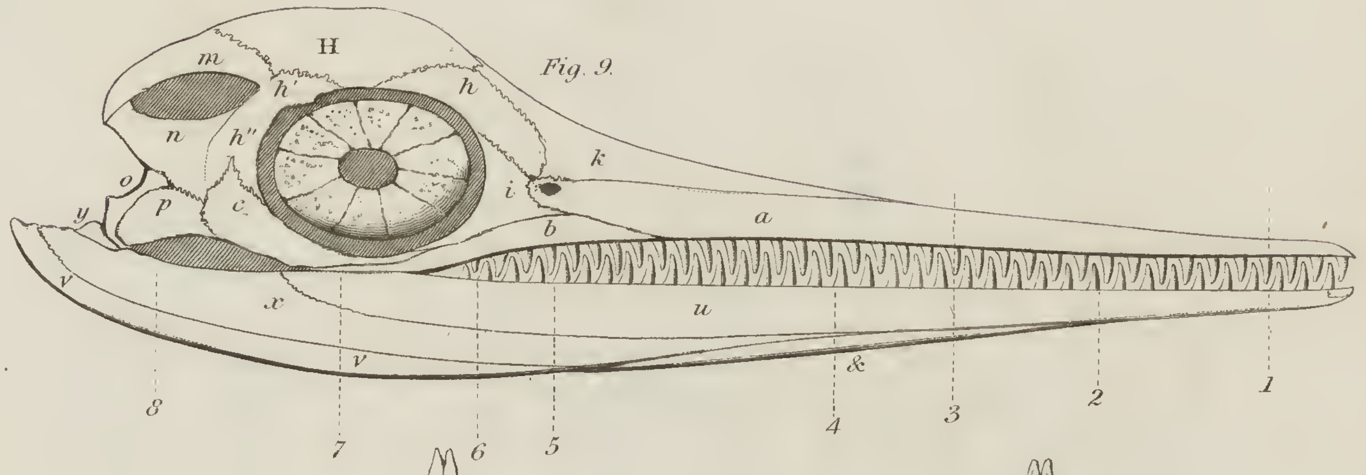

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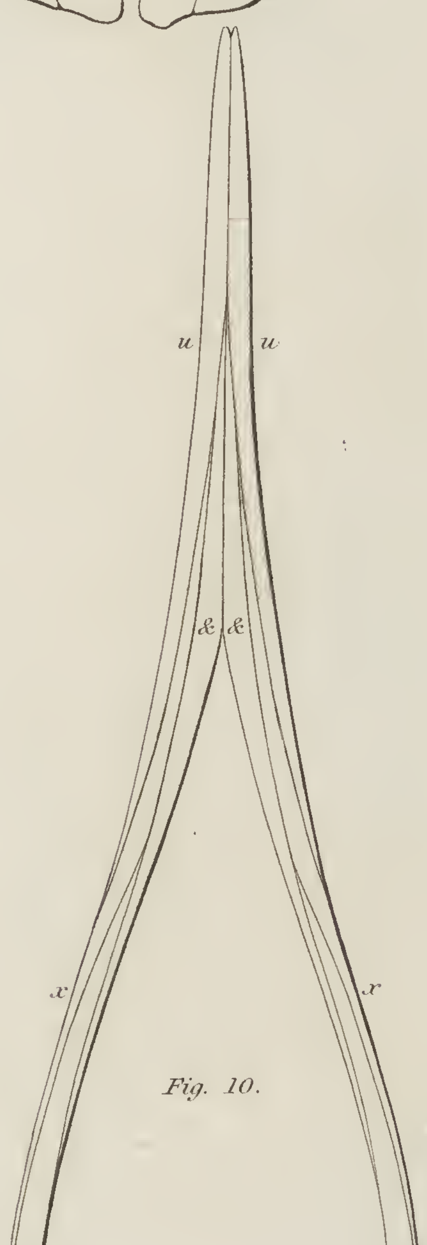

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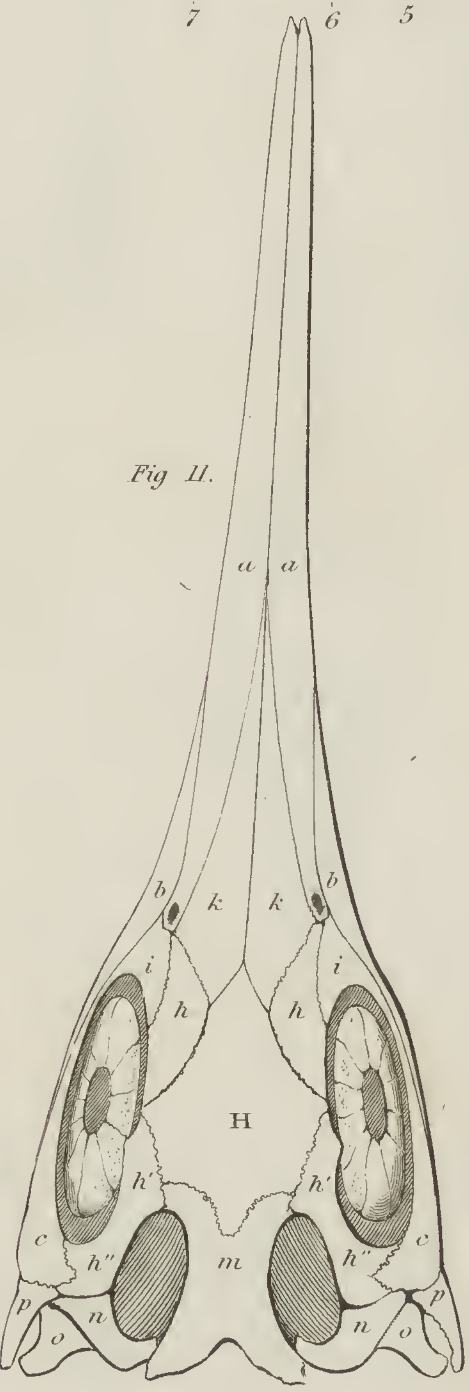

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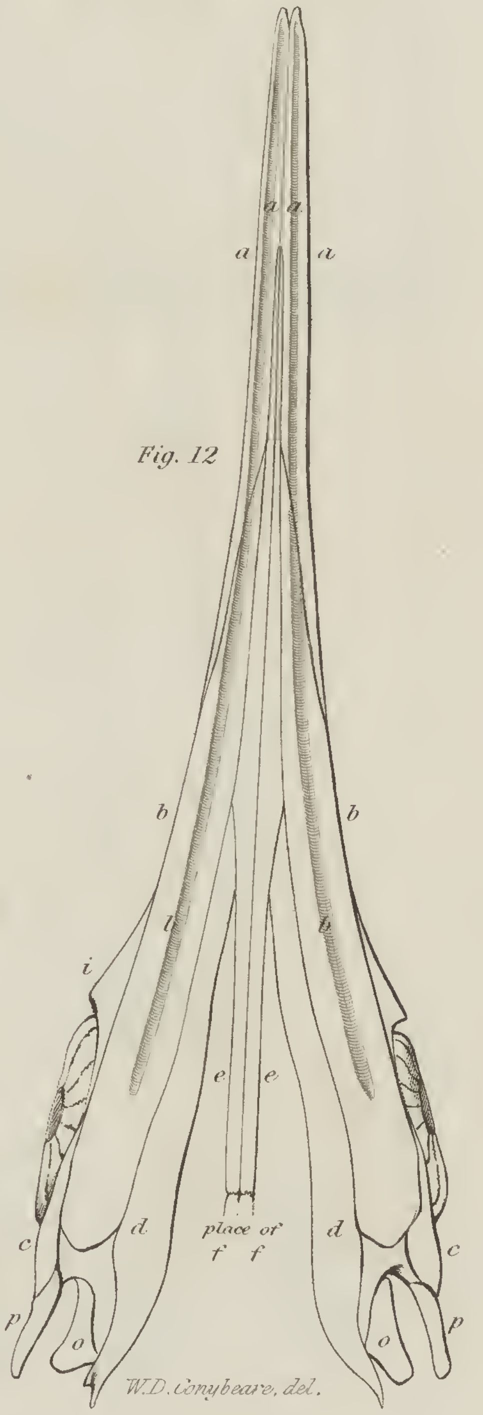

Fig. 12

W.D. Conybeare, del.

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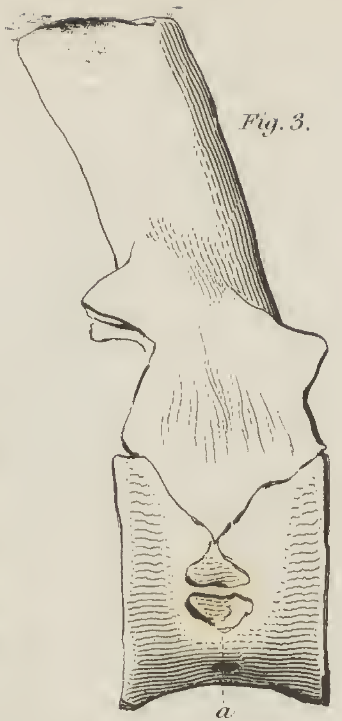
Fig. 3.



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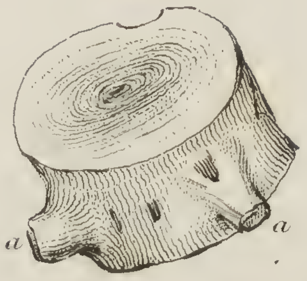

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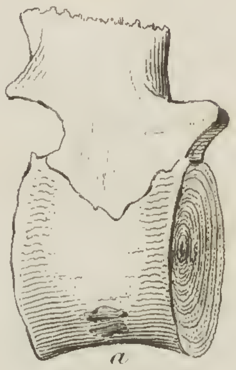

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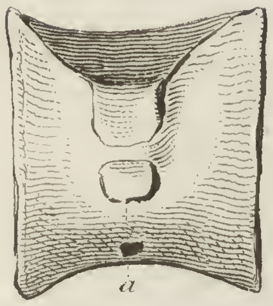

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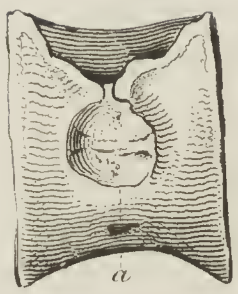

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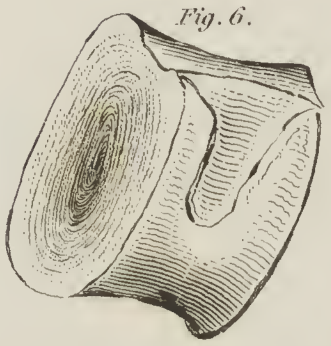

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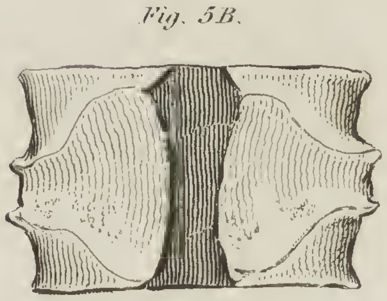

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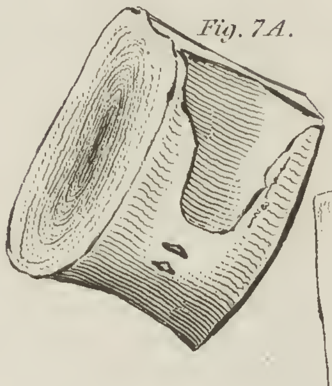

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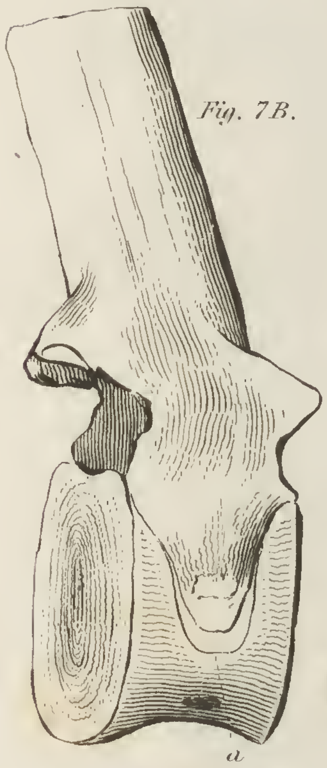

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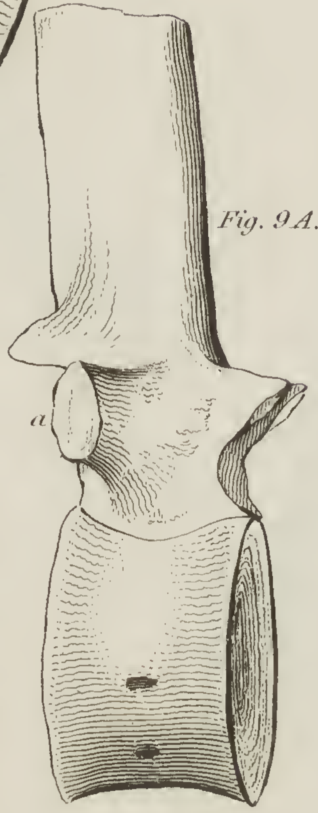

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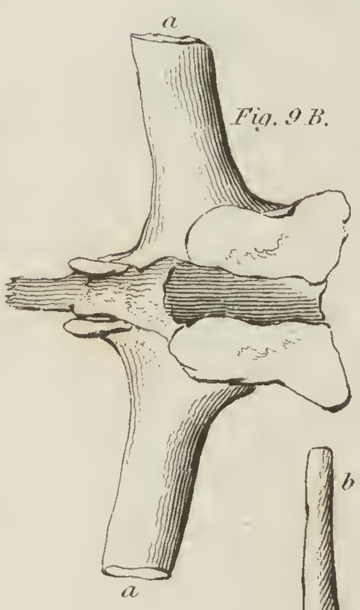

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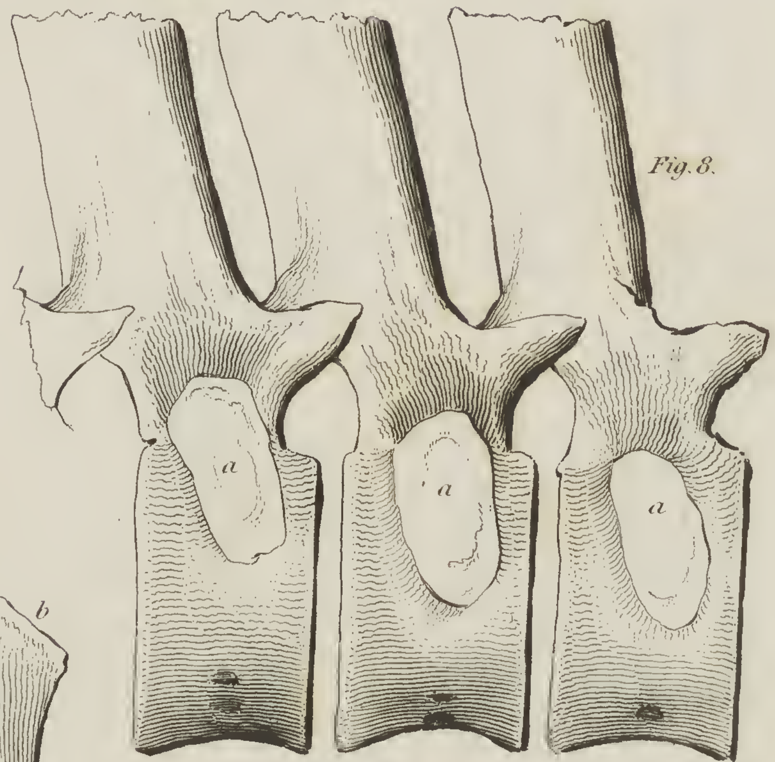

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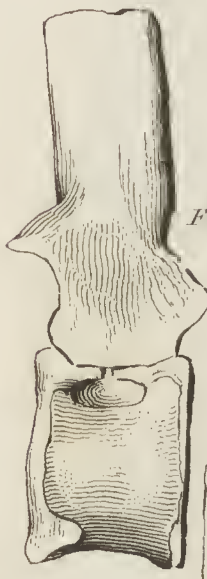

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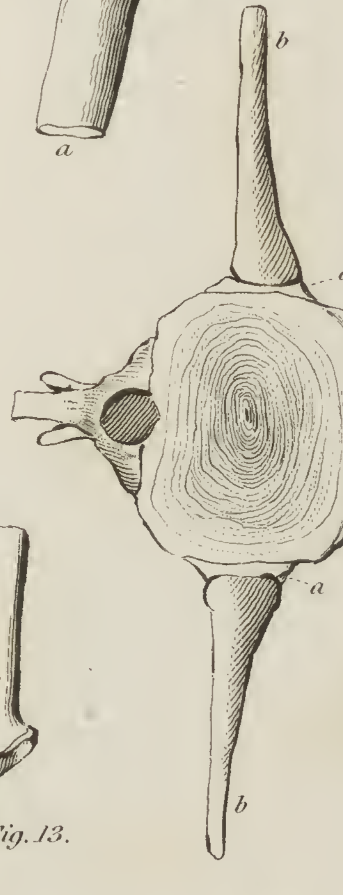

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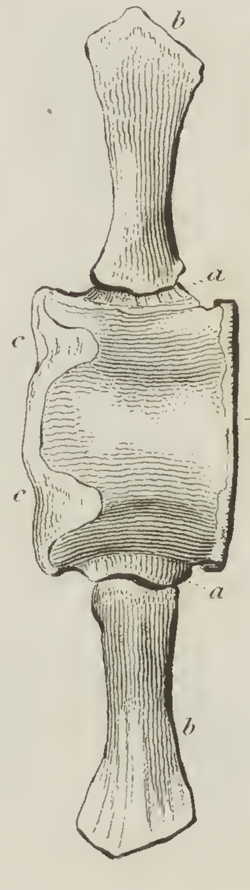

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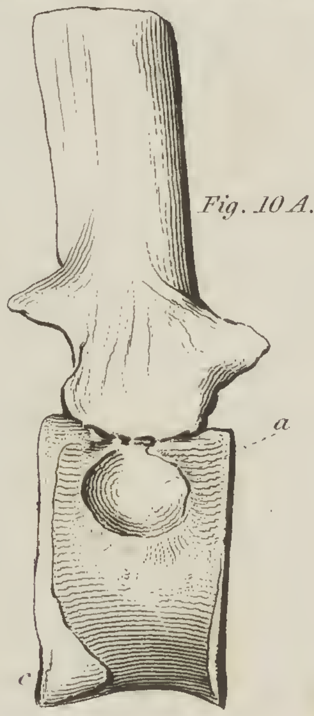

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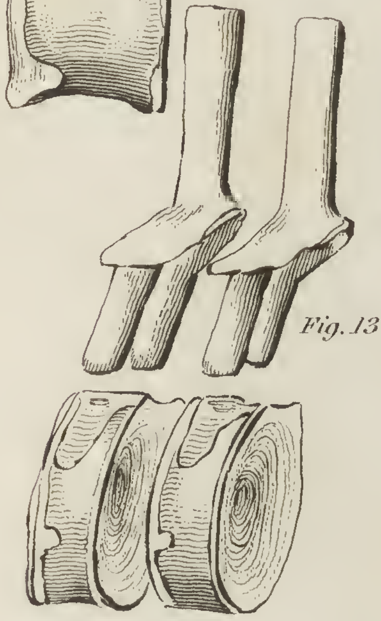

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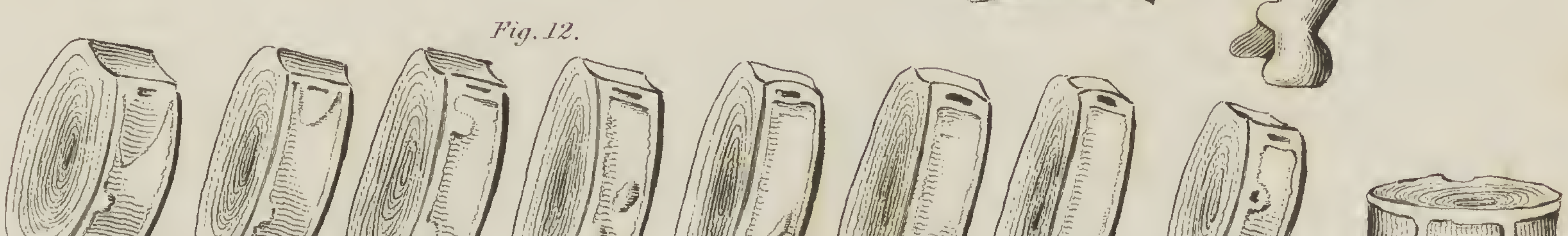

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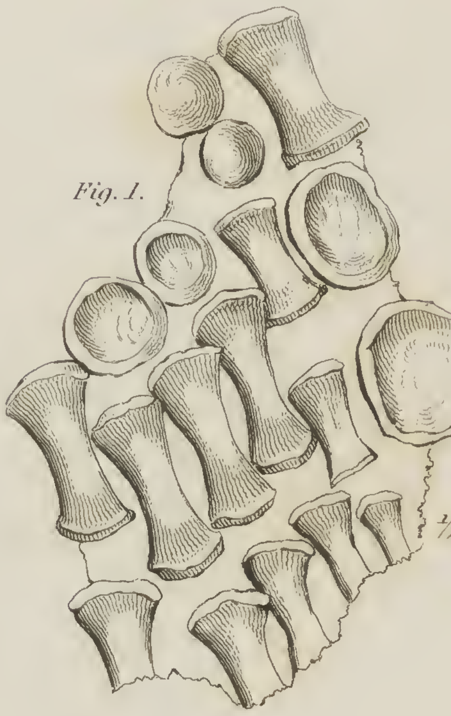

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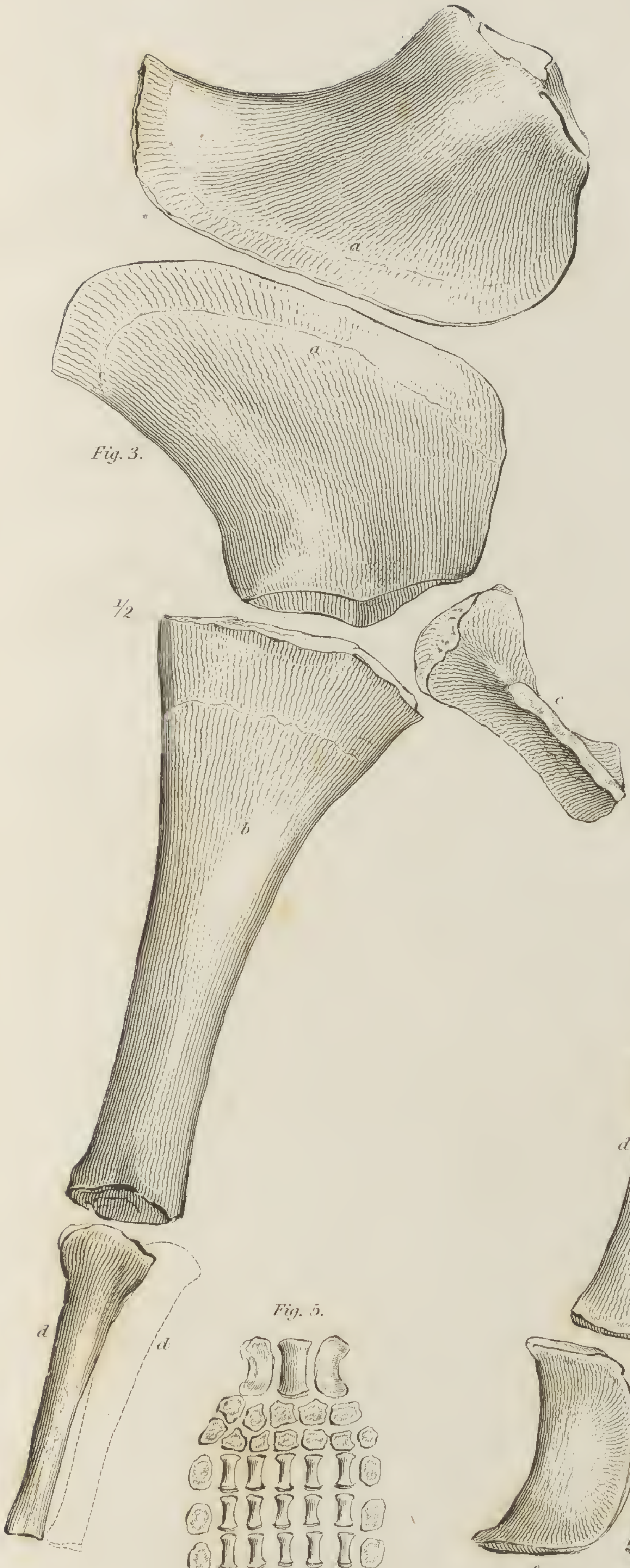

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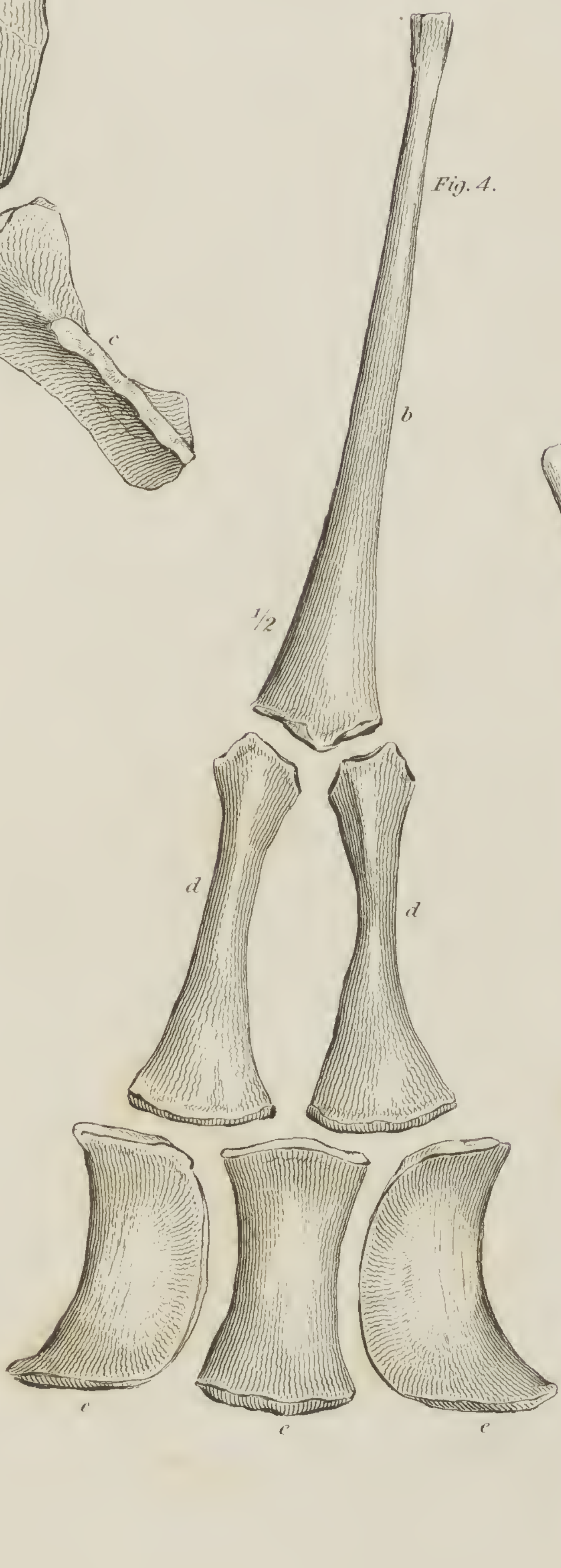

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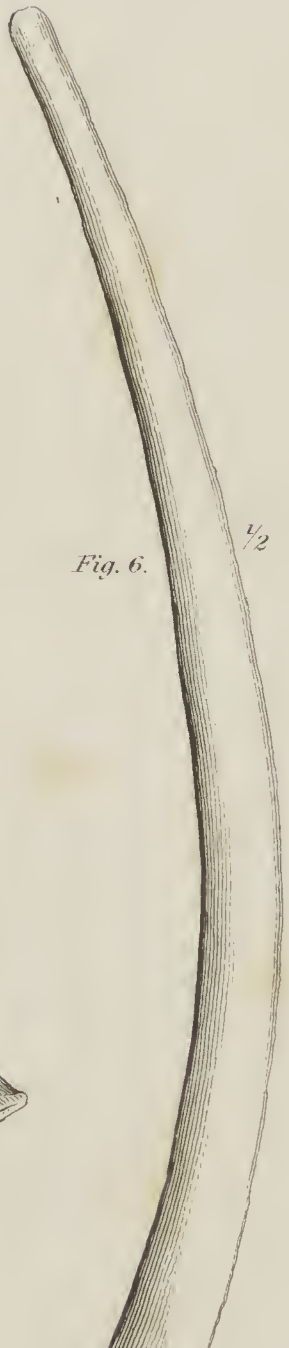

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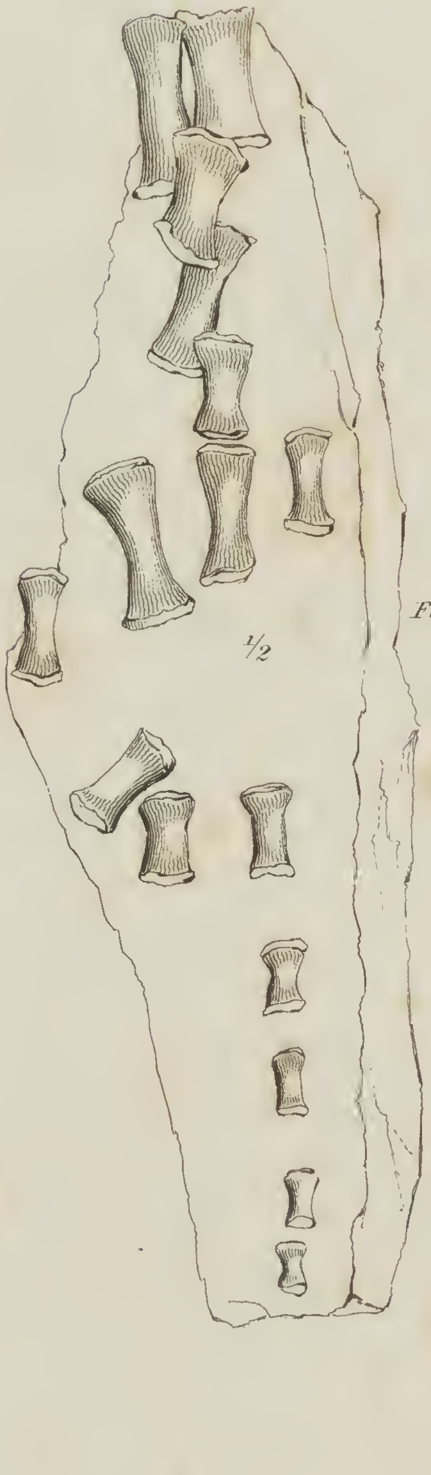

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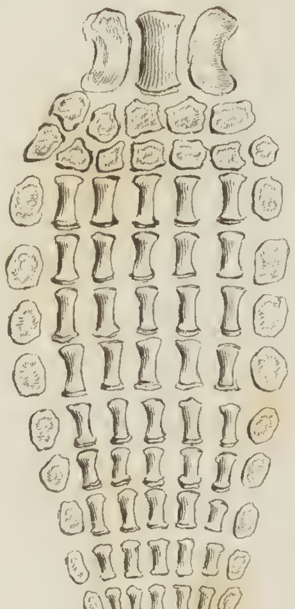

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